Rocky Mountain Forest and Range Experiment Station

1965 Annual Report

FOREST SERVICE

U.S. DEPARTMENT OF AGRICULTURE

PROJECT LOCATIONS

Albuquerque, New Mexico
New Federal Building

Flagstaff, Arizona
Forestry Sciences Laboratory
Arizona State College

Fort Collins, Colorado
Forestry Building
Colorado State University

Laramie, Wyoming
Forest Range and Watershed Laboratory
University of Wyoming

Lincoln, Nebraska
Plant Industry Building
University of Nebraska

Rapid City, South Dakota
Forestry Sciences Laboratory
South Dakota School of Mines
and Technology

Tempe, Arizona
Forest Hydrology Laboratory
Arizona State University

Tucson, Arizona
Tumamoc Hill
University of Arizona

Station headquarters is at Fort Collins, Colorado,
in cooperation with Colorado State University

ON THE COVER:

Architect's concept of the new headquarters building for the Rocky Mountain Forest and Range Experiment Station. Ground was broken for the new facility on the Colorado State University campus in November 1965, with completion expected early in 1967.

ANNUAL REPORT

1965

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

March 1966

Contents

A brief summary

Forest Economics Research concentrated on developing a sound foundation of physical and biological data for an economic analysis of the multiple use effects of watershed management alternatives. This work is centered at the 275,000-acre Beaver Creek Pilot Watershed in central Arizona. Progress was made in development of an economic model; the fundamental basis for water values was analyzed.

Preliminary results of converting a 323-acre watershed from pinyon-juniper woodland to grass by "cabling" the trees and planting grass in 1963 were analyzed. Results to date indicate no measurable change in yields of either water or sediment. An automatic sediment sampler was field tested and found to be highly satisfactory. This device, semiportable and battery powered, automatically draws a series of stream-water samples into a set of bottles for later laboratory analysis of suspended sediment.

Influence of pine trees on snow accumulation and melt in natural forest openings was studied. Snow accumulates along the edge of the timber in a strip whose width is 1-1/2 to 2 times the height of the trees. The most snow was held for the longest times in openings adjacent to pole and sapling stands.

A system for classifying areas within a watershed into productivity groups based on soil management areas and general topographic conditions was devised. It helps identify areas with different productive capacities for timber and herbage.

Forest Products Utilization Research moved ahead in studies to improve utilization of the region's timber resources. A preliminary analysis revealed that lower grade ponderosa pine logs can yield a high percentage of veneer suitable for sheathing grades of plywood.

A lumber dryer using solar energy was tested and compared with open air drying. This low-cost dryer does the job faster than the open air method, especially in winter.

Work continued on development of a laminated decking that will make effective use of lower grades of ponderosa pine lumber, offer advantages to builders, and thus improve market opportunities for the region's pine timber.

The search for profitable uses for low-value trees and for logging and milling wastes continues. Particle board samples made from Rocky Mountain juniper, alligator juniper, Arizona cypress, and lodgepole pine mill waste were evaluated.

Work on scaling ponderosa pine logs by weighing resulted in development of simple formulas for predicting cubic foot volume of a log from its weight, and for determining the ratio of log weight per cubic foot.

Range Management and Wildlife Habitat Research continued to emphasize growth and habitat requirements of plants and animals. In Arizona, plant growth inhibitors--phenolic acids and their derivatives--isolated from juniper litter were determined to be the primary cause for the lack of vegetation under individual trees. The inhibiting effects of the compounds were most pronounced in heavy soils with poor aeration and drainage.

Plant competition studies in Colorado mountain grasslands showed that cover and vigor of Thurber fescue increased when forbs were removed and plant nutrition deficiencies were compensated. However, addition of nitrogen and phosphorus appeared to have no beneficial effect on forbs in the same area even though grass competition was removed. In Wyoming, the relative productivity of soils derived from three major parent materials in the alpine-subalpine zone was increased more by using a combined nitrogen and phosphorus mixture than by adding either element alone.

Deer and elk show preference for boundaries between the forest and associated grasslands; however, small openings are important parts of their habitat. Deer pellet groups were more abundant within a 450-foot strip of forest adjacent to the border, while elk use seemed equally distributed within a 350-foot strip either side of the forest border. Small openings 20 acres or less in the forest improved the habitat for both kinds of animals.

Wildlife habitat research was strengthened in the Black Hills and National Grasslands of South Dakota. In a burn area in the Black Hills, the aspen type provided one-third of the total white-tailed deer use even though it provided only 12 percent of the study area. Sharp-tailed grouse in the short-grass plains used mainly grasslands during the spring and early summer, and croplands in the late summer and fall. In the winter, trees and shrubs provide food and cover.

Watershed Management Research is providing information needed to determine how best to protect and develop soil and water resources. The most logical place to look for increased supplies of high-quality water, or to improve timing of streamflow, is in the high-water-producing mountain watersheds. We are studying ways to increase and control the snowpack to delay the melt rate, to improve catchment areas by timber harvesting and snow fences, and to evaluate the forces responsible for controlling runoff. Work is also underway on avalanche control and methods of forecasting avalanche disasters which might occur as our mountain watersheds receive greater public use.

Effects of different timber cutting practices are being evaluated and new methods for managing chaparral and juniper lands are being tried to determine their influence on soil movement and increased water quality and quantity.

Eroded and deteriorated range and forest lands are receiving special treatment. New measures are being developed to control flood peaks and heavy sediment loads that originate from such areas in an attempt to bring these lands back into economic production.

Timber Management Research continued to emphasize forest regeneration methods. The struggle for moisture is proving to be a critical factor in competition between native grasses and ponderosa pine seedlings. The spring-growing Arizona fescue is more severe competition than summer-growing mountain muhly. A level of osmotic stress common in the Southwest in the spring reduces germination of ponderosa pine seed. Progress toward expressing the regeneration environment in meaningful terms is reflected in a series of equations that express heat index in terms of latitude and elevation.

Concentrations of deer and elk on clear-cuttings in mixed conifers have controlled aspen sprouting, but have also reduced survival of planted pines. Time of shedding and amount of ponderosa pine pollen released differ considerably from year to year. Drought curtailed height growth of jack pines in the Nebraska Sandhills. Substantial differences in rate of growth and color of foliage in winter were found among 36 provenances of Scots pine.

Forest Fire Research continued to provide knowledge needed to prescribe intensities of fire that will serve different purposes best. Twenty-five consecutive rainless days in September-October 1965 did not dry a ponderosa pine litter layer enough to permit burning the decomposing (F) layer. The litter layer may build up rapidly after a burn if the tree crowns are scorched. Amount of winter precipitation influences how much new growth will take place and how much old foliage will be retained on shrub live oak. This may be a critical factor in flammability of chaparral.

Forest Disease Research showed that amount of basal area growth of ponderosa pine in Arizona and New Mexico is related to degree of infection with dwarfmistletoe. New photographic methods showed that seed velocities of dwarfmistletoes are higher than previously estimated. Taxonomic studies indicate dwarfmistletoes are well represented in Mexico, and probably originated there.

A new disease of subalpine fir in Colorado, Scleroderris canker, reduced esthetic values of recreational areas in the Roosevelt National Forest. Cytospora canker of Douglas-fir reappeared on the Pike National Forest for the first time since 1928. The southern limits of Hypoxylon canker of aspen were extended to within 200 miles of the Mexican border in Arizona. Phomopsis blight of eastern redcedar was controlled with fungicides in the Great Plains.

Forest Insect Research continued to stress natural control of damaging insects with studies of biologies of a few pest insects and their parasites and predators. Thirty-seven species of primary insect parasites of the spruce budworm have been reared, seven of which are abundant or common. One of the species has possibilities for mass rearing. More than 15 kinds of mites, some of which may be predaceous, were found on the Black Hills beetle. Some progress was made on propagation of a polyhedrosis virus disease of the Great Basin tent caterpillar. Studies of attraction of the Black Hills beetle continued to show some promising applications. The emergence and flight period of the Black Hills beetle, the period when control must cease, was found to be fairly constant from year to year.

Details of these and other findings are presented in the following pages. Complete accounts of our research are released through various publications. An annotated list of publications issued in 1965 is included in the bibliography at the end of this report.

Raymond Price, Director

The Rocky Mountain Forest and Range Experiment Station's newest field facility, a Forest Hydrology Laboratory, was dedicated December 16. The Laboratory is located on the campus of Arizona State University, Tempe.

The Honorable Carl Hayden, senior senator from Arizona, gave the dedicatory address, then turned over the key to the Forest Hydrology Laboratory to Dr. George M. Jemison, now Deputy Chief of the Forest Service in charge of Research.

Forest Economics, Utilization, Marketing, and Recreation Research

Forest Economics

Evaluating multiple use effects of watershed treatment

The Beaver Creek Pilot Watershed, 275,000 acres of central Arizona covered with ponderosa pine[1] forests and pinyon-juniper woodlands, is being used as a "laboratory" in which we are testing and evaluating the economic effects of management practices designed to increase water yields (fig. E-1).

With growing population, agriculture, and industry in the Southwest, there is growing interest in obtaining more water from the watersheds. But watersheds provide man with more than just water. Getting more water may mean giving up something else. Thus proposed water-increasing schemes must be evaluated from a multiple use viewpoint.

On the Beaver Creek Pilot Watershed we are testing various land treatments to determine how they affect the yields (amounts and qualities) of each of the several multiple products of the land--water, timber, livestock forage, wildlife, and recreation. Collection and analysis of data on physical and biological relationships are the first steps.

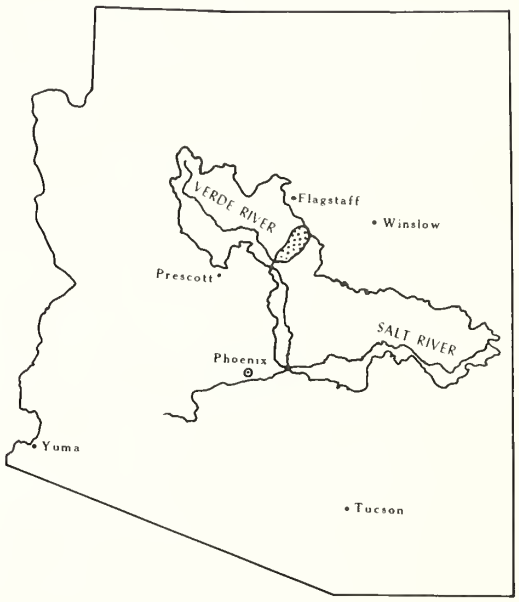


Figure E-1.--Economic data derived from the Beaver Creek Pilot Watershed south of Flagstaff will guide land managers throughout the Verde and Salt River watersheds.

Once physical and biological results are obtained, they will be subject to economic analysis. How much do the various land treatments cost? What returns (gains) do they yield? What do we give up (losses)? How do gains, losses, and costs balance out? What is the most efficient way of managing these watersheds? These are some of the questions we are trying to answer on Beaver Creek.

[1]*Common and scientific names of animals and plants mentioned are listed inside the back cover. Those for diseases and insects are included in text since many are identified only by their scientific names.*

Value of additional water analyzed

Choices among the various possible ways of managing a watershed depend partly on the values of the several products of the land. Values of timber, water, forage, and so forth depend on how people use these raw materials --sometimes at great distances from the watershed where they originate. Water values pertinent to Beaver Creek are derived from use of water by farmers on the Salt River Project in the Phoenix area.

Suppose additional water is produced through watershed management and used downstream for agricultural production. How much would it be worth? To analyze this problem, economists at the University of Arizona, working under a cooperative agreement, developed an economic model of the Salt River Project agriculture.

They found that without additional water, agricultural net income will decline, over the years, as the ground-water table falls, and costs of pumping and crop production increase. The value of additional water from upstream watersheds, delivered through the Salt River Project, would depend on how the additional water prevents future losses of income.

The value of successive additions of 1/2 acre-foot of water per acre of cropland was calculated under conditions of (a) constant technology of agricultural production, (b) constant cropland acreage in the Project, (c) stable cost-price relationships, and (d) stable government crop programs.

It was found that, at a 6 percent rate of interest, Project farmers could pay up to $4.40 each year for the first 1/2 acre-foot of new water per acre. The second 1/2 acre-foot would be worth $3.72 each year, and the annual value of the third and fourth 1/2 acre-foot additions would be $3.14 and $1.19 respectively.

These values also indicate the amounts that downstream farmers can pay each year to finance water-yield-improving treatments and management on upstream watersheds such as Beaver Creek.

Higher interest rates would reduce the amounts farmers could pay for additional water from the Salt-Verde River system; lower interest rates would increase the values.

Preliminary results of converting from woodland to grass

In 1963, Utah juniper and pinyon pine trees on a 323-acre watershed were uprooted by tractor-drawn cables (fig. E-2). The cleared area was seeded to grass after the downed trees were burned.

So far, changing the watershed cover from juniper woodland to grass has not measurably changed water or sediment yields. Herbage production has increased some, but much of the increase has been by relatively low-valued forbs and shrubs. The trees removed were not commercially important. There were 6 to 8 cords of wood per acre, and annual growth was about 1/13 to 1/16 cord per acre.

A more complete evaluation will be made after additional data are collected.

Automatic sediment sampler field tested on Beaver Creek

A new automatic sampler, developed by the Federal Interagency Sedimentation Project to sample sediment suspended in streams, has been field tested on the Beaver Creek project (fig. E-3). This new device, with its shelter, can be moved from one location to another and can be powered by batteries where electrical lines are not available. It has the unique advantage that samples can be collected automatically over a period of time without an attendant being present. Samples of water are drawn from the stream into pint bottles by a clock-activated pump. The stream-water samples are analyzed later in a laboratory to determine concentration and size distribution of sediment suspended in the water.

Field tests showed the automatic device samples suspended sediment quite accurately. During the winter, 70 percent of the pump

Figure E-2.--Watershed with the juniper and pinyon trees uprooted and ready to burn. Grass was planted on cleared watershed.

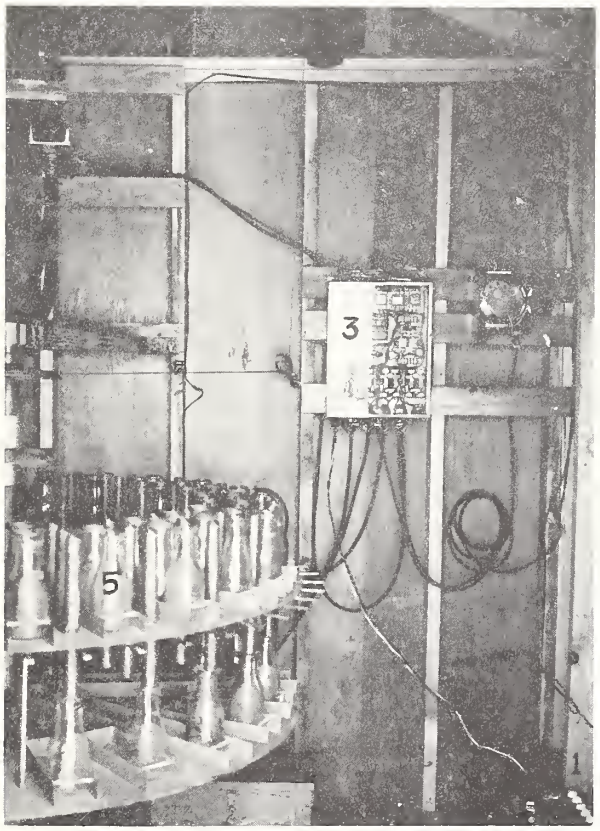


Figure E-3.--Equipment inside the automatic sampler shelter includes: (1) 36-volt battery power supply, (2) clock with timing gear, (3) control box, (4) splitter, (5) bottling wheel holding pint bottles. Not shown are the pump and flush water supply.

samples were within 20 percent of the average actual sediment concentration in the stream. During summer flows, over 90 percent of the automatically taken samples were within 10 percent of the average actual sediment concentration.

The device worked well over a wide range of conditions. Sediment concentrations during winter streamflow varied from 0 to 4,000 p.p.m. During summer flows, concentrations were as high as 51,400 p.p.m. Sediment in sand sizes varied from 0 to 65 percent. Streamflow varied from 0 to 1,200 cubic feet per second (c.f.s.).

Pine trees influence snow accumulation and melt

Pine forests on Beaver Creek contain many natural openings (fig. E-4). How various forest conditions affect snow accumulation and melt in these adjacent openings was studied to help in developing improved watershed management methods. Measurements were made on the downwind side of the timber edge.

It was found that:

1. For all tree heights and stocking conditions studied, snow was held in a "zone of retention" at the edge of the forest openings for distances of 1-1/2 to 2 times the height of the trees (1-1/2 to 2H).

Figure E-4.--Ponderosa pine in central Arizona occurs on rolling topography. The pine stands include many natural openings.

2. Further out, at distances beyond 2H, snow disappeared from the openings after each snowstorm.
3. Forty percent of the winter precipitation that fell in a band 1H wide adjacent to the canopy was held until just prior to the start of spring runoff.
4. A sapling and pole stand (fig. E-5) held the most snow just prior to spring runoff, and had a relatively rapid melt rate in the spring. Such characteristics would be desirable for maximizing surface runoff in a short time period.
5. An uneven-aged stand with a basal area of 135 square feet held a small amount of snow through the winter and melted it slowly in the spring. These characteristics would be desirable for minimizing surface runoff or extending the timing of runoff.
6. An even-aged large sawtimber stand held almost no snow throughout the winter but it had a fairly rapid spring melt rate.

Ponderosa pine sites grouped by soils and topography

A rapid method for grouping areas as to productivity was developed for use on the Beaver Creek watershed. Areas were divided into four groups based on two soil management areas and two general topographic situations. The different groups could be de-

Figure E-5.--Typical band of snow along northeast edge of a sapling and pole stand. The snow shown is what remained after several days of rapid melt; the stakes are at distances of one-half and one tree height from the edge of the canopy on the left.

lineated quickly by use of soil maps, aerial photographs, or topographic maps, and limited ground checks. The criteria used in the ground checks to identify soil management areas were: (1) depth to clay or silty clay, (2) surface rockiness, and (3) surface color. The two soil management areas were subdivided into "swale" and "upland" situations based on topography and percent slope.

Division of areas by this method was found to be effective in estimating productivity for both herbage and timber. The areas which produce the most timber growth also produce the most herbage when the timber is removed; likewise the areas with the lowest potential for timber also are lowest for herbage.

These groupings are useful for reducing the sampling variance for herbage production on areas cleared of timber and for timber site index on areas supporting timber. This type of grouping is expected to be useful in planning for the multiple use management of watersheds.

Preference ratings of forage species determined

Ponderosa pine forests and pinyon-juniper woodlands on Beaver Creek include forbs, grasses, and shrubs useful for livestock grazing. Because plants are not used equally by livestock, the relative use of various grasses was analyzed and preference ratings were developed. Rating of I indicates the species most preferred by cattle. Each unit increase in the rating indicates 10 percent less utilization. Bottlebrush squirreltail was used as the base plant for a standard of comparison.

Preference rating	Ponderosa pine forest. summer use	Pinyon juniper woodland. spring and fall use
I	Kentucky bluegrass	Prairie Junegrass
II	Arizona fescue Mountain muhly Pine dropseed Black dropseed Bromes	Bottlebrush squirreltail
III	Spike muhly Mutton bluegrass Sedges Bottlebrush squirreltail	Side-oats grama Mutton bluegrass
IV	Blue grama Prairie Junegrass	Black dropseed
V	--	Blue grama Spike muhly

Forest Utilization

Plywood potential of southwestern ponderosa pine studied

Much of the southwestern ponderosa pine timber is of low quality and yields high proportions of lower common grades of lumber. Also, plywood has replaced lower grade lumber in most construction uses. Hence, research was continued to determine whether lower quality southwestern ponderosa pine logs can yield the volume and grade of veneer necessary for production of sheathing grade plywood, and also whether suitable logs can be identified in the forest.

Study logs were selected from typical standing trees (fig. U-1) and processed under controlled conditions in a commercial veneer plant. Volume and grade of veneer yield were related to log quality and other log characteristics.

Veneer volume and grade recovery were excellent. From 73 to 97 percent of the veneer was C or D grade, suitable for sheathing plywood (fig. U-2). Up to 25 percent was suitable for use in sanded plywood. Very little veneer, 2-1/2 percent or less, was unsuitable for any commercial plywood.

Actual yields varied among log quality classes. Better logs yielded about three-fourths sheathing grade veneers and about one-fourth sanded grade. Logs in the lower quality classes generally yielded veneers mostly suited for sheathing plywood.

Figure U-1.--Study logs for veneer production were selected and classified in standing trees to achieve desired sampling distribution and better describe the timber being sampled.

Location of the log in the standing tree was found to be important in determining veneer grade recovery. In general, about 20 percent of the veneer from butt logs was suitable for sanded plywood and about 78 percent for sheathing. Middle and upper logs yielded veneer of which 90 percent could be used for sheathing plywood, and only 8 percent for sanded plywood.

Laminated decking may improve market for ponderosa pine

Laminated floor or roof decking shows considerable promise for more effective utilization of the lower grades of ponderosa pine lumber common to the Black Hills. Because this decking is made up of three laminations--face, core, and back--defects can be placed where they have least effect on strength or appearance. Strength of the decking can be engineered by varying the grade and thickness of the outer laminations (fig. U-3). Studies are underway to find out what minimum grades and thickness combinations are needed for the span loads common to house construction.

Suitability of various species for particle board determined

Efforts continue to develop profitable uses for low-value trees, and for logging and mill-

Figure U-2.--Grade C veneers (two panels on right) may have knots up to 1-1/2 inches and holes up to 1 inch. Grade D veneers (three panels on left) may have knots without limit, and holes up to 2-1/2 inches.

Figure U-3.--Test panel of laminated decking fabricated from Black Hills ponderosa pine.

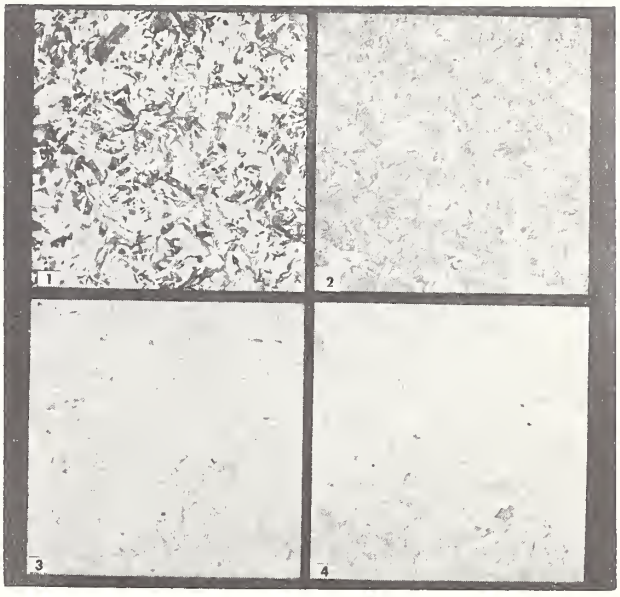


Figure U-4.--Samples of particle board made from low-value species and milling residue. (1) Rocky Mountain juniper; (2) Alligator juniper; (3) Arizona cypress; (4) Lodgepole pine.

ing wastes. Rocky Mountain juniper, alligator juniper, and Arizona cypress trees and lodgepole pine mill wastes were evaluated for possible use in particle board (fig. U-4). All test material was converted to 1-inch-long flakes, 0.15 inch thick, and then bonded with 8 percent urea resin to a density of 40 pounds per cubic foot.

Satisfactory particle board was made from these species, with the possible exception of alligator juniper. Test panels of alligator juniper showed abnormal linear dimensional movement and low strength, particularly stiffness. Rocky Mountain juniper and Arizona cypress panels also showed greater linear dimensional movement than those of the species commonly used in particle board.

Lumber dries faster, more completely, in a solar dryer

Freshly sawn 4/4 Engelmann spruce lumber dried faster and to a lower final moisture content in a solar-heated dryer (fig. U-5) than in a conventional air-drying yard. The initial moisture content of the lumber to be dried in the solar dryer was about 90 percent, compared to only 60 percent for the lumber to be air-dried, yet both reached 18 percent in 5 days. Lumber in the solar dryer came down to 10 percent moisture content in 10 days, but air-dried stock required 22 days to reach 11.6 percent. There was no noticeable difference in degrade by the two methods.

The temperature differential between inside and outside the loaded dryer varied from 10° to 20° F.; a 10° difference was maintained overnight.

The covering of relatively clear corrugated fiberglas was more satisfactory than the clear plastic film used previously.

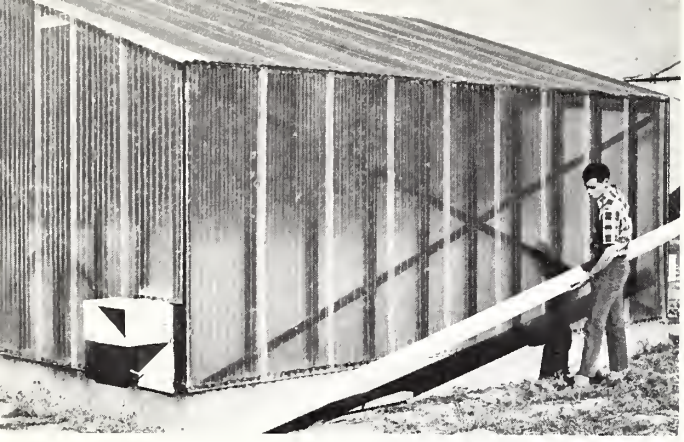


Figure U-5.--Solar kiln sheathed with corrugated fiberglas.

Black Hills ponderosa pine logs can be weight scaled

A study of weight scaling ponderosa pine logs in the Black Hills to determine cubic foot volumes reveals that:

1. Cubic foot volumes and ratios of weight per cubic foot can be predicted.
2. Annual variation in the breast-high moisture content of the sapwood caused calculated weights of 37 logs to vary an average of 8.5 percent.
3. Weight loss in woods-stored logs does not appear to limit weight scaling seriously, especially if the logs are weighed before degrade due to insect and/or blue stain attack occurs.

Three variables were used to develop cubic-foot-volume prediction formulas. Weight was the best single variable, and can be used alone to determine statistically accurate volumes. Log diameter and percent defect factors significantly improved the volume prediction formula, but a specific gravity factor did not.

Variation in the weight-per-cubic-foot ratio for 223 logs was also investigated. Results indicate this ratio can be predicted from log size and percent moisture content, but these variables explained only 63 percent of the variation.

Moisture content of the sapwood at breast height in live ponderosa pine trees varied significantly between both seasons and sites. Winter and spring moisture contents were higher, by about 24 percent, than late summer and fall moisture contents (fig. U-6). For 37 logs, with sapwood making up from 5 to 99 percent of their volume, calculated "winter" weights averaged 8.5 percent higher than "summer" weights, with a range of from 6 to 10 percent. Throughout the year, trees on higher quality growing sites had about 10 percent more moisture in the sapwood than trees on lower quality sites, irrespective of apparent soil moisture availability. Heartwood moisture content for all sites and seasons remained stable at near 30 percent.

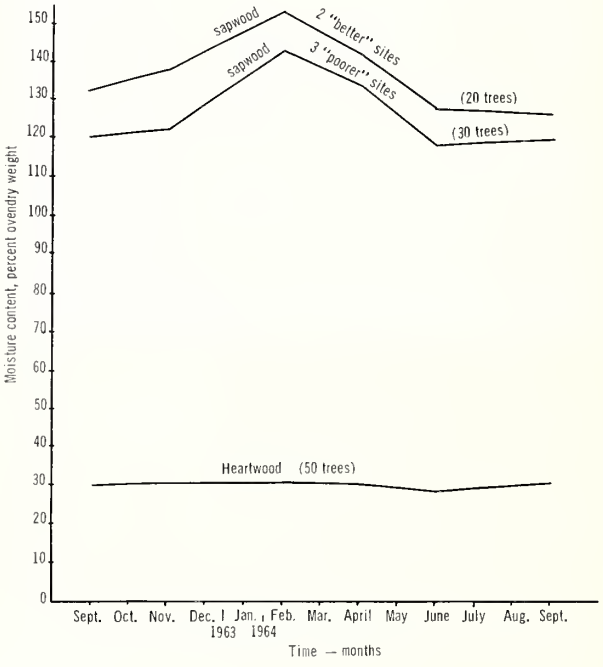


Figure U-6.--Annual variations in moisture content of ponderosa pine tree stems, Black Hills, South Dakota.

Logs stored in the woods lost only 5.3 percent of their beginning weight during about 104 drying days. However, serious blue stain and insect attack occurred by the time weight loss had reached 3 percent. Weight loss of logs held in woods storage would benefit the buyer of logs purchased by weight. The small advantage soon would be lost, however, if logs were damaged by blue stain or beetles.

Range and Wildlife Habitat Management Research

Range Management

Steers usually maintain sufficient protein intake by selective grazing

Steers grazing southwestern grass-shrub ranges compensate for apparent low protein in perennial grasses, the bulk of the diet, by selectively grazing other forages with more crude protein. Only during the summer growing season did the average crude protein content for perennial grasses on the Santa Rita Experimental Range exceed 9 percent, the generally accepted requirement for growing or lactating cattle grazing range herbage (fig. R-1). However, rumen samples taken periodically from fistulated steers throughout the yearlong grazing season exceeded or equaled the 9 percent protein level at all times except midwinter. The animals selected forbs high in crude protein in the spring when the summer-growing perennial grasses were dormant.

In the summer and fall, the steers used foliage from browse species and seasonally growing plants to supplement their protein intake from grasses. Only in winter, when choice of forage was most limited and the average protein content of all species lowest, did the average crude protein intake appear deficient. It appears that dietary protein intake may be moderately deficient during late spring and early summer, and that supplements would probably be needed during midwinter.

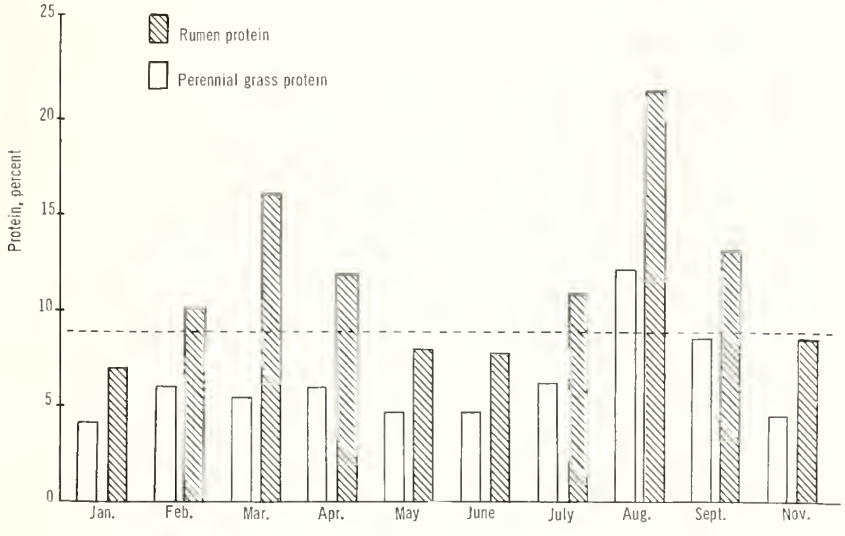


Figure R-1.--Crude protein content of the perennial grasses and rumen contents from the fistulated steers.

One growing season after mesquite control and reseeding to Lehmann lovegrass, native Arizona cottontop was the dominant grass on this area.

After a few years, however, the Lehmann lovegrass became dominant and Arizona cottontop was inconspicuous.

Figure R-2.--Lehmann lovegrass may replace native perennial grass.

Lehmann lovegrass: an aggressive competitor on Southwest semidesert ranges

In 1954, Lehmann lovegrass was aerially seeded at a rate of 1 pound per acre on a 100-acre area of the Santa Rita Experimental Range in southern Arizona that had been treated to kill velvet mesquite. An unexpectedly good stand of native perennial grasses developed that year, and only a few lovegrass seedlings were established. Ten years later, however, the lovegrass produced 974 pounds of herbage per acre, while native perennial grasses produced only 242 pounds (fig. R-2).

Juniper litter inhibits blue grama

The absence of blue grama under Utah juniper trees on northern Arizona ranges (fig. R-3) is due primarily to chemical inhibitors from the tree litter, not to competition for light and soil moisture. Solvent separations, paper chromatography, and colorimetric spot tests indicate that the principal active inhibitors are phenolic acids and their derivatives.

The inhibiting effect is more pronounced on heavy soils with poor aeration and drainage. Soil micro-organisms responsible for the breakdown of the toxic substances were fewer on the heavy soils--700 colonies per gram of soil as compared to 5,300 colonies in the lighter soils--and percolation was not as great.

It has been assumed that juniper trees compete strongly with grasses for soil moisture, and that removal of trees would therefore release space on and in the soil for increased grass production. In some cases this is undoubtedly true, especially with deep-rooted species. With shallow-rooted species such as blue grama, however, whose roots are concentrated in the upper 6-12 inches of soil, this assumption is invalid. Therefore, when trees are removed in control projects, significant production increases by such species

Figure R-3.--Chemical inhibitors from the accumulated tree litter reduce growth of blue grama more than competition for light and soil moisture.

should not be expected until the tree litter at least partially decomposes and accumulated toxins are broken down or leached from the soil.

Crested wheatgrass stands independent of seeding rates and row spacings

Crested wheatgrass stands in northern New Mexico apparently reach an equilibrium with the habitat within 5 to 8 years after seeding, regardless of seeding rate or row spacing. Herbage yields were essentially the same for 2-, 4-, and 6-pound per acre seeding rates and for 6-, 12-, and 18-inch row spacings in the fifth, sixth, and eighth year after seeding. Yields were not significantly higher from wide spacings during a drought year or narrow spacings during a wet year. Density and size of the wheatgrass plants in the eighth year after seeding showed no important differences regardless of seeding rate or spacing.

Seeded range recommendations--ponderosa pine zone

A mixture of crested wheatgrass with inoculated yellow sweetclover plus smooth brome appears to be the most promising seeded range for sustained forage and livestock production in the ponderosa pine zone of the Front Range of Colorado. This recommendation is based upon 12 years' experience with grazing, at several intensities on the Manitou Experimental Range.

Grazing of mixture stands can begin when spring growth averages 4 inches. Stocking should be sufficient to use available forage to an average 2-inch stubble height during the grazing season. The stand will appear uniformly used when grazed to this level. Similar recommendations apply to pure crested wheatgrass ranges, although production will likely be somewhat less than from mixture ranges.

Where the principal need is for early forage, Russian wildrye may be used, although animal weight gains may be less than from the mixture ranges. Grazing to a 3-inch stubble height is recommended.

Neither smooth brome nor intermediate wheatgrass can be recommended for seeding as a single species on drier upland sites of the pine zone. Even when grazed to only a 6-inch stubble height, stands of both species diminished and were invaded by low-value native species.

Drought affects crested wheatgrass more than season of grazing

Short-term drought has caused much more drastic plant responses than 7 years of season-of-grazing treatments on crested wheatgrass ranges at the Manitou Experimental Range, Colorado.

After a few years, plants on ranges grazed only in the fall tended to aggregate into relatively large but few distinct clumps. Plants on the spring and spring-fall grazed ranges became smaller and more numerous. Then in the seventh year of treatment, rainfall was only 51 percent of average in the first 4 months of the growing season. Plants responded to the drought immediately on all ranges (fig. R-4). Portions of the large clumps on the fall-grazed ranges died, leaving a stand of smaller individuals. Entire plants died on spring and spring-fall ranges. Thus, as the result of a drought year, conditions were comparable to those at the start of the grazing treatments, all ranges retained the same relative ranking in production, density, and basal area.

Forbs and Thurber fescue competitive

Vigor and cover of Thurber fescue increased significantly on experimental plots in the mountain grassland type near Crawford, Colorado, when competing forbs were removed, and nitrogen and phosphorus were added. Cover of Fremont geranium, the most abundant forb in this area, and other broadleaved plants increased when grass competition was removed, but did not improve with fertilization. In fact, on plots from which all forbs and grasses had been removed, the use of nitrogen and phosphorus apparently depressed forb recovery (fig. R-5).

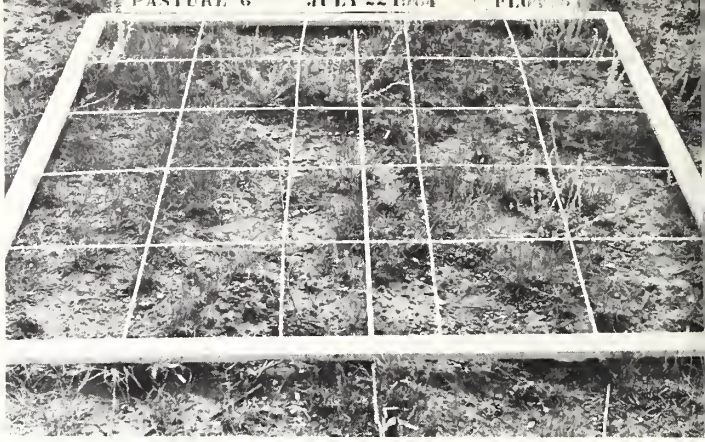


Figure R-4.--Microplot on crested wheatgrass range grazed both spring and fall.

Prior to the drought in 1963, living plants formed good cover.

After the drought, many plants died reducing ground cover considerably.

Productivity of three alpine soils differs

Important differences were found in productivity of soils derived from three major parent materials on alpine-subalpine sheep ranges in Wyoming. In greenhouse pot tests, oat yield on soils derived from glacial till was approximately 80 percent greater than on soils from volcanic ash; 55 percent greater than on soils from volcanic breccia.

Nitrogen, applied as ammonium nitrate at the rate of 80 pounds per acre, increased yield by 25, 110, and 58 percent on till, breccia, and ash soils, respectively. Phosphorus, added as calcium phosphate at 200 pounds per acre, increased yield by 80 percent on the till soil, but had little effect on the other two soils.

The combined effect of nitrogen and phosphorus increased yields on all soils more than either element alone. The combination of elements increased yield on the ash- and breccia-derived soils by 200 and 225 percent, respectively. The increase on glacial till soil was only 128 percent.

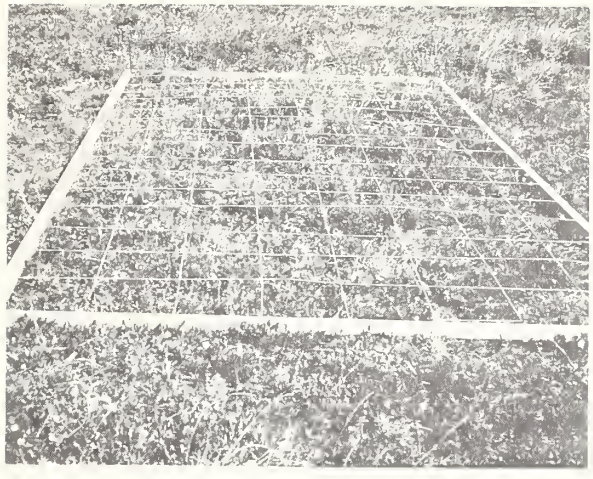
Herbicides control alpine avens

Alpine avens, an abundant but unpalatable forb on Rocky Mountain alpine sheep ranges, can be controlled effectively with 2,4-D and 2,4,5-T. Applications of 1 or 2 pounds per acre of either material reduced the density of the species in experimental plots by 92 and 98 percent, respectively (fig. R-6).

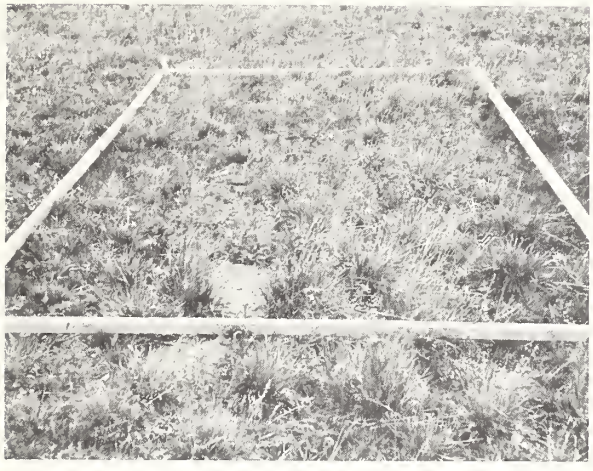
Figure R-5.--Addition of nitrogen and phosphorus apparently depressed forbs on denuded plots.

Elements added

No amendments



Prior to treatment, 1963.



Two years after treatment, 1965.

Figure R-6.--Alpine avens control with herbicides on Rocky Mountain alpine sheep ranges.

These results were obtained in a cooperative study with the University of Wyoming. The herbicide should be applied as soon as the alpine areas are accessible in the spring, which usually corresponds to the early bloom stage of the plant.

Wildlife Habitat

Importance of edge effect for deer and elk in Southwest demonstrated

Deer prefer a narrow strip within the forest immediately adjacent to the forest border, while elk favor equally well the transition areas between the forest and openings. These facts were demonstrated by observations within the mixed-conifer forest zone of the Kaibab and Apache National Forests. Results were similar for both natural openings and openings created by logging.

Deer pellet groups were most abundant within a 450-foot strip of forest adjacent to the border; they decreased gradually at greater distances into the forest, and fell off sharply out into the openings (fig. WH-1). Elk use was concentrated within a 350-foot strip on either side of the forest border.

Cattle use, indicated by droppings, was concentrated in natural openings. They made some use of the forest border, but beyond 400 feet there was little use. In contrast to big game, cattle used openings created by logging slightly less than the adjacent forest.

Deer habitat improved by selective logging of mixed-conifer forests

Deer use of selectively logged areas in mixed-conifer forests of New Mexico and Arizona was about one-third greater than in unlogged areas. In the logged areas, basal area of overstory trees was reduced by about one-half. This reduction in overstory contributed to a fivefold increase in herbaceous understory vegetation, although there was a comparatively small absolute increase. These facts were learned by comparing 10 paired logged and unlogged areas:

	Unlogged	Logged
Tree overstory, basal area (Square feet per acre)	157	78
Herbaceous understory (Pounds per acre)	15	70
Deer droppings (Groups per acre)	3.1	4.3

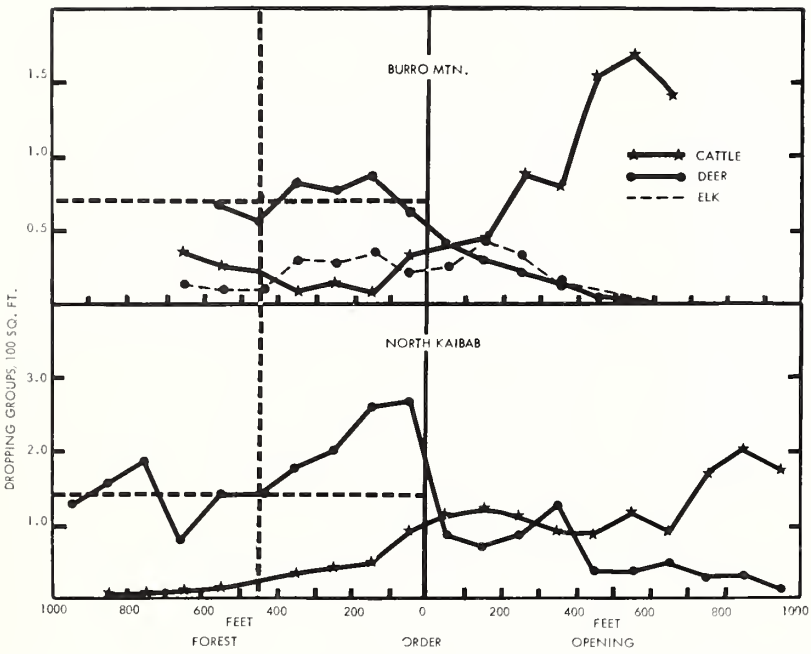


Figure WH-1.--Relation of abundance of the dropping groups of deer, elk, and cattle to spruce-fir forest, forest borders, and openings.

Deer prefer logged areas where slash is undisturbed

Measurements in a logged-over ponderosa pine forest in northern Arizona indicate deer prefer areas where slash was not disturbed (fig. WH-2). Deer use was five times greater in these areas as compared to areas where the slash had been cleaned up after logging. Since forage conditions and forest overstory were similar in both areas, abundance of slash was the apparent cause for differences in use. The undisturbed slash may contribute additional cover needed by the deer.

Small openings required by deer and elk

Small openings are important for deer and elk in southwestern mixed-conifer forests. Relative use of these openings declined sharply, except around the edges, as size of the opening increased beyond 20 acres. As the openings became smaller, relative use by both animals increased. To be most beneficial to deer and elk, openings made in the mixed-conifer forest should thus be 20 acres or less.

Figure WH-2.--A ponderosa pine forest on the Kaibab Plateau, cut over without any slash cleanup in 1953. Deer favor these areas over those where slash is piled and burned.

Aspen type important to white-tailed deer

In the McVey Burn, an important winter range in the Black Hills of South Dakota, white-tailed deer prefer the aspen type to other vegetation types. Although aspen thickets occupied only about 12 percent of the study area, they provided one-third of the total use.

A dry south slope with a mixture of grasses and forbs, which occupied 84 percent of the study area, received proportionately much less use than any other part of the area. Chokecherry and serviceberry occupied about 1 percent of the area as small patches along drainages. These highly preferred deer forage species were heavily utilized. Kentucky bluegrass bottoms covered the remainder of the area.

The range evidently supports about one deer per 3.5 acres during the 5 winter and spring months' use.

Prairie grouse prefer varied habitats

The greater prairie chicken (fig. WH-3) and the sharp-tailed grouse occupy the same prairie and brushland habitat in the south-central portion of South Dakota west of the Missouri River. The sharp-tailed range extends additionally throughout the western part of the State and includes portions of the Black Hills.

Figure WH-3.--Greater prairie chicken male (left), in displaying position alongside female, prefers short grass or mowed areas for booming grounds.

The seasonal habitat requirements of the sharp-tailed grouse vary throughout the year. A grassy habitat, especially mid-grasses such as western wheatgrass and green needlegrass, is preferred during the spring and early summer. In the late summer and for most of the fall, the birds depend primarily on cropland. In the winter, habitats with trees provide food and cover for the birds (fig. WH-4).

Figure WH-4.--The plains subspecies of sharp-tailed grouse feeds on tree buds during the winter months.

Forest Biology

(In cooperation with the Fish and Wildlife Service, U. S. Department of the Interior)

Pocket gophers have high population turnover

Mountain pocket gophers have a rapid population turnover, based on fall population inventories on Black Mesa Experimental Range in western Colorado. Fall estimates are that the life span of the pocket gopher averages 1-1/2 to 2 years.

Fall inventories and age ratios indicate that young animals comprise a major part of

the population when gopher numbers are high, and a small part when numbers are low. Young-of-the-year animals comprised 66 to 77 percent of the population when there were 19 to 20 pocket gophers per acre, but only 13 percent when there were 5 gophers per acre.

Mountain pocket gophers are being studied on Black Mesa to determine if grazing intensity has any influence on their abundance, because these animals usually are considered detrimental to range production. Their burrowing penetrates the root zone of herbage plants, and mound building disturbs soil and covers aboveground vegetation (fig. B-1).

Holes penetrate the root zone of herbaceous vegetation.

Figure B-1.--Mountain pocket gophers are active on Black Mesa where:

Mound building covers aboveground vegetation.

Mountain pocket gophers don't travel far

When pocket gophers were trapped, marked, released, and retrapped several times on Black Mesa, the mean closest distance between an individual pocket gopher and its nearest neighbor was found to be 31 feet. The greatest distance between capture points for individual pocket gophers was also measured. The mean for these measurements was 77 feet. Since these measurements reflect burrow system activity, and adult gophers live in solitary burrow systems during the nonbreeding season, they indicate size of territory and population of pocket gophers. At the time these summer measurements were made, the pocket gopher densities varied from 12 to 20 animals per acre, populations considered to be moderately high.

One pocket gopher (fig. B-2) was live-trapped, marked, and released during 4 consecutive summers. The greatest distance between trapping points was only 120 feet.

Figure B-2.--For 4 successive years, this mountain pocket gopher was live trapped, numbered and released on the same study plot at Black Mesa.

The length of several burrow systems in summer was also determined by digging to expose the tunnels. Average length of the long axis of a burrow system was 42 feet. This is greater than the distance between nearest neighbors and less than the maximum distance between trap catches mentioned above.

Burrows seen in the snow during the winter and spring can be much longer than these underground burrows during the summer.

One to six deer mice per acre on Black Mesa

Deer mice populations are small in Thurber fescue grasslands of Black Mesa as measured by trapping studies over the last 12 years. Populations have varied from 1 to 6 animals per acre.

During the 6-year period 1960-65, numbers have varied from one to three animals per acre. With these populations the "mean observed range length" (maximum distance between capture sites for individual animals that were trapped, marked, released, and retrapped fig. B-3), varied from 110 to 249 feet, and tended to vary inversely with the population density.

Figure B-3.--Deer mice were live trapped, marked, and released on grazed areas at Black Mesa to determine number of animals per acre and to learn about their movements.

Abundance of deer mice in relation to intensity of cattle grazing, and their relationship to range vegetation are under study at the Black Mesa Experimental Range.

Montane voles show population high on Black Mesa

Thirty-seven montane voles were caught in snap traps on permanent transect lines in July 1965 at Black Mesa Experimental Range. This was the highest catch recorded for the transects in 9 years of sampling; none were taken in 1961. The highest vole catches followed, by 1 year, years of most precipitation.

When voles are abundant they are considered detrimental to range vegetation because of the amount of herbage they consume and waste (fig. B-4).

Figure B-4.--Montane voles clipped these Thurber fescue stems and left them on ground.

Mule deer eat juniper and oaks in Arizona

Leaves and fruit of woody plants and forbs made up about 97 percent of the volume of food in 32 rumen samples taken from mule deer in fall and early winter on the Beaver Creek Watershed, Coconino National Forest, Arizona. The food volume for these plant categories was divided about equally between woody plants and forbs. Juniper, Gambel oak, and shrub live oak leaves were the most prominent tree and shrub food items. Most common forbs in the rumen were Louisiana wormwood, birdbeak, toadflax penstemon, buckwheat, and goldeneye. Although parts of

Figure B-5.--Merriam turkey feeding along the edge of a natural opening on the Apache National Forest, Arizona.

grass and grasslike plants occurred frequently in the samples, they comprised only about 1 percent of the total food volume at this season of the year.

Merriam turkey ecology under study in Arizona

The ecology of the wild turkey is under study in the White Mountain Apache Indian Reservation in eastern Arizona. The study area, at an altitude ranging from 5,000 to 7,000 feet includes both pinyon-juniper and ponderosa pine type habitat (fig. B-5). One of the highest turkey populations in the Southwest is found in the area.

The study includes measurements of turkey habitat requirements and development of guidelines for managing the habitat in a manner compatible with other uses. Food, water, and roosting requirements, daily and seasonal movements, production and survival, and effect of environmental factors on production are all being measured.

Shrubs are important deer and elk food in pinyon-juniper type

Analysis of rumen samples from 12 deer and 10 elk taken on a study area in southern New Mexico during the 1963 and 1964 hunting seasons showed that shrubs constitute approximately 80 percent of their diet in October and November. Birchleaf cercocarpus was first and oak second in the diets of both deer and elk. For deer, skunkbush sumac was of third importance; for elk, all grasses, principally blue grama ranked third in rumen contents.

Fifteen additional species of trees, shrubs, and forbs occurred in one or more of the rumen specimens. In all instances, however, the percent by volume was less than 5 percent.

Watershed Management Research

Streamflow measured by dye dilution

An accurate, inexpensive method of gaging streamflow is now being developed based on the injection, dilution, and subsequent remeasurement of a fluorescent dye in a stream. A methanol-water solution of Rhodamine B is added to a stream (fig. W-1) at a known rate. After the dye has mixed completely with the streamflow, its concentration will be registered downstream on a clock-fed strip of absorbent paper. The amount of dye retained in the paper can then be determined later in a laboratory with a fluorometer. The ratio between initial and downstream dye concentrations will give a measure of streamflow. Measurements made over a period of time could provide hydrologists with an accurate picture of seasonal patterns of streamflow.

Figure W-1.--Dye injection station for inexpensive streamflow measurements.

Adding dye to the stream will not impair water quality. Only a minute amount of dye will be added, and the dye used is soon destroyed by both sunlight and oxygen in turbulent mountain streams.

Hydrologic characteristics of big sagebrush

Hydrologic effects are of prime importance in spraying programs for control of big sagebrush being tested near Dubois, Wyoming (fig. W-2). Three small watersheds have been gaged prior to treatment. The first treatment was applied this year--80 to 90 percent of the big sagebrush on the watershed was killed by chemical spray. Effects on the quantity and timing of water yield, snow accumulation, sediment yield, and vegetation production will be evaluated.

Wetland hydrology

The small bogs common along many perennial streams in the Rocky Mountain area may significantly affect management techniques for water yield improvement. To provide information on these small water-holding areas, hydrologic characteristics of a 3-acre

Figure W-2.--Spraying big sagebrush near Dubois, Wyoming for water yield improvement.

spikesedge bog at 9,000 feet are being studied: water-table fluctuations, potential evapotranspiration, water permeability, and moisture-retention characteristics of the peat. Quality of water from above the bog (fig. W-3), the bog, and a perennial stream flowing from the bog, is also being measured to determine potability and to detect quality changes over the summer months.

Figure W-3.--Upland ground water samples are collected from wells in timbered land above the bog to evaluate water-table fluctuations and water quality.

Velocity of sapflow varies

Some valuable knowledge about variations in velocity of sapflow with depth into the xylem, and with time during different days of the year, was gained at Fraser Experimental Forest, Colorado.

The velocity at different depths was measured with probes placed at regular intervals into the xylem (fig. W-4). The sap velocities

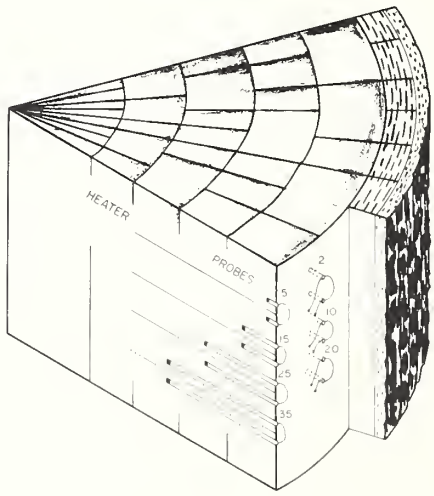


Figure W-4.--Schematic diagram of the probes inserted to various depths (in millimeters) in the xylem of a tree to measure sap velocity.

at three times of the year are shown in figure W-5. Note there is little movement in the outermost layers.

The variation in velocity with time during 3 different days is shown in figure W-6. The July and September traces were taken when the soil was dry; the June reading when the soil was wet. The interesting point is that the traces made during the dry season indicate movement continuously throughout the night, while the one during the wet season does not. This type of trace, then, is an indication of water availability to the plants under different soil moisture stresses. Such knowledge may prove useful in deciding what trees could be cut from a watershed to increase water yield.

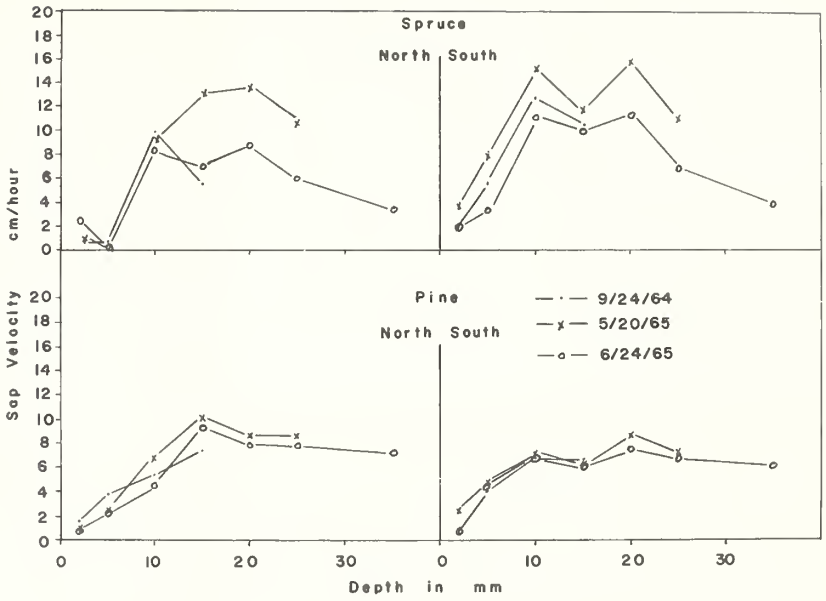


Figure W-5.--Sap velocity as a function of depth in the xylem on 3 different days.

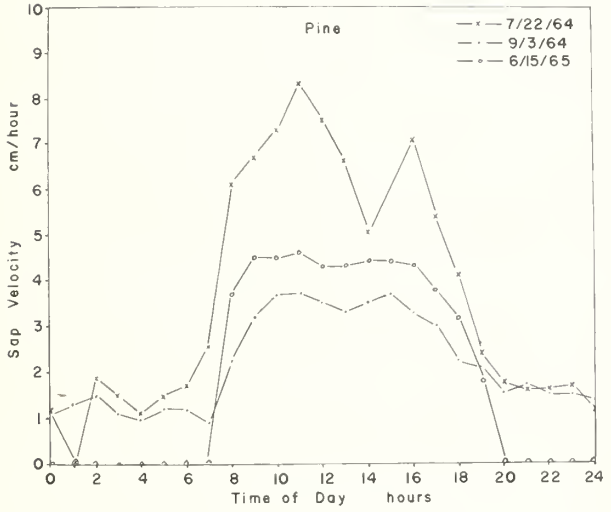


Figure W-6.--Variation in sap velocity with time of day. Note sap flow ceased at night on June 15, when soil was wet.

Snow still accumulates in 24-year-old openings

Snow accumulation on twenty 8-acre plots was measured before and after various degrees of harvest cutting in 1940. The amount of snow held was increased by the cutting, with the greatest increase on clearcut plots. Measurements taken again in 1964 indicate regrowth for 24 years has not influenced snow accumulation. In the following tabulation, water content of snow is expressed as a percent of that on uncut plots:

Merchantable reserve stand, (bd. ft. per acre)	Water content of snow Mean, 1941-43	1964
11,900 (uncut)	100	100
6,000	119	117
4,000	129	131
2,000	143	142
0	144	140

Reproduction, fairly dense on clearcut plots, has reached heights of 15 to 20 feet, yet snow trapping and holding characteristics have changed little. Young trees seem to be protected by the surrounding forest, and exert no detrimental effect on snow deposition.

Rime ice adds water to snowpack in northern New Mexico

Supercooled water from fog and clouds freezes to form rime ice frequently in the Sangre de Cristo Range of New Mexico. The rime usually forms at elevations above 10,000 feet during storms with abundant cloudiness and high wind velocities. After a storm on

January 7, 1965, an average water equivalent of about 0.20 inch was measured under aspen canopies. Rime ice from the spruce-fir canopies contributed about half as much, 0.09 inch of moisture. Most rime trapped by spruce is held in the canopies until it sublimates, whereas aspen canopies allow most of the rime to fall during the thawing period. During an average winter season of several rime-producing storms, an additional inch of water may be added to the snowpack on the high-elevation watersheds.

Measuring physical properties of snow slabs

Most avalanches result when cohesive snow layers--called snow slabs--fracture and slide down the mountain. Although snow slabs are known to form as the result of wind action, not much is known about the correlation between weather factors and the type of slab formed.

The first step in developing this correlation is to learn how to measure certain physical and mechanical properties of the wind-toughened snow. Test equipment has been built and field tested, and field procedures developed to measure ultimate strength and air permeability of snow.

Tests have been made on the fracture line of one hard slab avalanche and two soft slab avalanches. Air permeability measurements were consistent within a given layer of snow, but the ultimate strength varied from place to place within the layer and with the type of instrument used. Several new tensile strength instruments will be tested during the coming winter.

Water yield potential varies with vegetation type

Soil moisture under grass, aspen, and mixed conifer types was studied in the White Mountains of east-central Arizona to determine water-yield potentials. Except for surface runoff during storms or snowmelt, soil moisture must be recharged to field capacity before mountain watersheds yield any water.

During the 3-year study, water was always available for streamflow from the grassland type during winter because the soils were above field capacity, and the average annual surplus precipitation of 9.7 inches either was added to the water yield as runoff or deep percolation, or was evaporated.

Under aspen, the 3-year average water-yield potential was only 2.10 inches. Because aspen soils had an average moisture deficit of 1.8 inches to be satisfied, the soils were too dry to allow water to percolate through. Excess precipitation may have been accounted for as either surface runoff or evaporation.

Mixed conifer areas showed a 7.2-inch surplus of winter precipitation, but an average moisture deficit of 5 inches remained to be satisfied. This surplus moisture was probably lost by interception or other unmeasured evaporation losses, because no runoff occurred.

A soil moisture deficit is created by the evapotranspiration process during the summer growing season. This study shows that the entire growing season's precipitation is utilized, as well as considerable amounts of stored soil moisture. Aspen was the heaviest water user, with a 3-year average of 23.7 inches per year, as compared to 18.7 inches for mixed conifers and 17.2 inches for grass. Water use by mixed conifers could conceivably have been greater if the entire depth of soil had been wet after the snowmelt period.

Conversion of burned chaparral to grass improves water yield, reduces sediment movement

About 3 inches of water have been saved for each of the last 3 years by converting resprouting burned chaparral to grass on the Three-Bar watersheds in Arizona. The increase in yield became evident soon after the the second annual postfire brush control treatment.

Four annual treatments with 2,4,5-T and one treatment with Fenuron have kept shrub crown cover to less than 10 percent on the grassed watershed (fig. W-7), while untreated brush on the check watershed has returned to

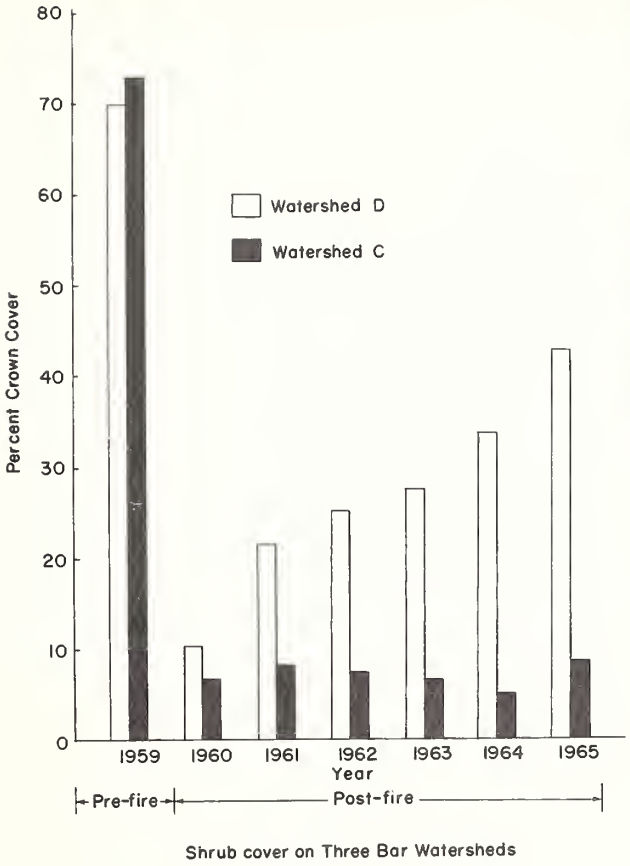


Figure W-7.--Post-fire chaparral sprouts have been greatly retarded by four annual chemical treatments on watershed C (upper right). Brush is recovering naturally on watershed D.

two-thirds of its prefire crown cover of 70 percent. Production of herbaceous plants has continued to increase on the treated watershed, while gradually decreasing on the untreated area.

Movement of sediment from the watershed returning to brush continues at a moderate rate after receding from the heavy losses of the early postfire period. Currently, low sediment movement from the treated watershed suggests that the excellent grass cover offers as good or better protection than the naturally recovering brush.

Effect of timber harvest on water and sediment being studied in Arizona

A timber harvest treatment was started on the West Fork of Castle Creek (fig. W-8) about 20 miles south of Alpine, Arizona, in June 1965 to determine what effects current methods of harvesting ponderosa pine timber have on water and sediment yields. The forest, almost pure ponderosa pine, averages 12,000 board feet per acre.

Two watersheds, the East and West Forks, were instrumented in 1956. Water yield measurements show a good relationship between the two watersheds, so effects of timber harvest can be determined by comparing flows from the treated West Fork with those from the uncut East Fork.

Under this timber harvest treatment, five-sixths of the West Fork watershed is being placed in the best growing condition for the existing virgin stand by removing:

1. poor risk and overmature trees,
2. mature trees where necessary to release needed age classes,
3. trees that overtop or crowd residual crop trees,
4. poorly formed and other poor classes of trees,
5. damaged trees, and
6. all dwarfmistletoe-infected trees.

The remaining one-sixth of a watershed is being clearcut in blocks where there are only overmature, or overmature and unneeded age classes. If natural regeneration does not give a satisfactory start toward even-aged management, these clearcut blocks will be artificially regenerated. It is probable that the cleared areas will yield more water until they are again occupied by forest vegetation.

Prior to harvest cut

A clearcut opening

Figure W-8.--A study area on West Fork of Castle Creek, Arizona, to evaluate the effect of timber harvest on water and sediment yield.

Thinning in progress

Thinning completed

Timber Management and Forest Protection Research

Timber Management

Clearcuttings in Arizona mixed conifers have failed to regenerate

Seven clearcuttings in mixed conifers on Burro Creek, Apache National Forest, contain little natural reproduction 5 years after cutting and slash treatment. Five units were clearcut and two were cleared of all commercial trees in 1958 and 1959. Four slash treatments--machine piling and burning, hand piling and burning, broadcast burning, and no treatment--were completed in 1960. In June 1965, only three seedlings of postlogging origin one or more years old were found on 829 sample milacres. Because of the uniform failure, no differences developed between cutting and slash treatments.

Limited seed supply, seed- and seedling-eating pests, and competition from aggressive low vegetation combined to exclude new trees.

We have no record of the 1959 and 1960 seed crops. But 1961, 1962, and 1963 seed crops of 255,000, 21,000, and 146,000 seeds per acre in uncut timber spread an average of only 31,000, 8,000, and 24,000 seeds per acre over a 10-acre unit. These numbers of seeds might prove adequate on well-prepared sites that are kept free of rodents and cutworms, but proved inadequate in this case. By 1964, when a bumper crop of seed came along, the ground was completely occupied by competitive vegetation (fig. T-1) which nurtures a visibly high population of voles, other rodents, and ground-inhabiting insects.

The frequency of such failures can be minimized by taking corrective steps immediately after logging and slash treatment:

1. Prepare a receptive seedbed.
2. Reduce the seed-eating rodents.
3. Assure a good first-year seed supply, even if it has to be applied by hand.

Big-game browsing reduces planting success in Arizona mixed conifers

Ponderosa pines were planted on one of the seven clearcuttings on Burro Creek, Apache National Forest, in 1961. Seventy-three percent of the trees died in the first 15 months,

Figure T-1.--Five years after timber was cut and slash was burned, Burro Creek clearcuttings are densely vegetated but understocked with tree reproduction.

most of them from unknown causes. Two deer and elk exclosures were constructed in September 1962. There has been little mortality of planted trees inside the exclosure since that time, and survivors are growing well. Most of the trees outside the exclosures that survived the initial heavy mortality have since succumbed to browsing. The few that still live are not permitted to grow (fig. T-2).

Figure T-2.--Ponderosa pines five growing seasons after planting. Seedling on left is from a big game exclosure. Four on right show heavily browsed condition of most seedlings outside the exclosure.

Progress made on environmental description

The length and warmth of the growing season varies substantially within the central and southern Rocky Mountains, even within a vegetation zone. An index of summer heat has been developed based on the length and warmth of the vegetative season. Heat index is one of several environmental indexes being developed for site description in Colorado and northern New Mexico. For the east slope of the Rockies in Colorado, the equation is:

$$H = 800.326 - 9.756\,L - 0.0800\,LE$$

where H = heat index,
L = latitude in degrees,
E = elevation in hundreds of feet.

Pine seedlings need more water to survive

The struggle for soil moisture appears to be the main factor in competition between grass and ponderosa pine seedlings. At the end of the first growing season, pine seedlings survived equally well (69 to 73 percent) on plots densely vegetated with Arizona fescue, mountain muhly, or from which all vegetation had been scalped, as long as the plots were watered frequently. On unwatered plots, only 13 percent of the pines survived in fescue cover and 31 percent in muhly, compared with 44 percent in scalped plots. Arizona fescue is a spring-season grower; mountain muhly is a summer-season grower.

Needle moisture content (based on ovendry weight) less than 110 percent combined with a relative turgidity less than 60 percent seems to be critical for seedling survival. Seedlings in watered plots remained above those levels at all times, whereas seedlings in unwatered plots were near or below those levels, especially in Arizona fescue at the end of the drought in July.

Heavy snow damages thinned trees

Heavy, wet snows in the winter of 1964-65 caused extensive damage to young ponderosa pine in northern Arizona that had stood through two winters after thinning. The snows bent or broke up to 17 percent of the trees on some level-of-growing-stock study plots (fig. T-3). Tall, spindly trees with a low diameter-to-total-height ratio were most commonly damaged.

Figure T-3.--Young ponderosa pines damaged by heavy, wet snows on the Taylor Woods thinning plots.

Seed germination reduced under moisture stress

Germination of ponderosa pine seeds was reduced by moderate soil moisture stresses in the laboratory. Germination was about 24 percent lower when seeds were watered with a mannitol solution having an osmotic stress of -8 atmospheres compared to seeds treated with tap water. Water stress also reduced the germinative energy of the seeds. Water stresses greater than -8 atmospheres commonly occur during the annual drought periods in the Southwest.

Timing and amounts of pine pollen shed in the Black Hills

Release of ponderosa pine pollen peaks suddenly, then lasts for several weeks in the Black Hills. The amounts collected went from zero to maximum for the season in only 1 week of both 1963 and 1964. Both timing and amounts differed greatly between years, however. First pollen was measured on June 25, 1963, and on June 10, 1964. The maximum caught in 1 week was only 80 grains in 1963 but 5,727 in 1964 (fig. T-4). The latter sample indicates that about 230 billion pollen grains were released per acre in 1 week.

Figure T-4.--The pollen grains were caught in a film of petroleum jelly on a glass slide mounted in the pollen trap.

Drought changes site index for jack pine in the Nebraska Sandhills

Under the site index concept, based on the average relationship between age and total height of dominant trees, we assume that short-term fluctuations in growth rates due to variability of environmental factors will "average out" over a rotation period. That assumption is not always valid. Long-term records indicate that the drought of the 1930's lowered the indicated quality of a jack pine plantation site in the Sandhills of Nebraska by approximately one 10-foot site index class.

The trees were planted in 1911; the drought, roughly a decade of moisture stress, occurred between the 21st and 36th years (fig. T-5). Heights at age 21 indicated a site index of slightly over 50, whereas heights at age 36 indicated a site index of about 40. Although deviations from normal patterns of height growth upset the accuracy of site index estimation, they can help identify abnormal growing conditions. Deviations from normal growth patterns are proving valuable measures of the impact of adverse factors on tree growth on the Plains.

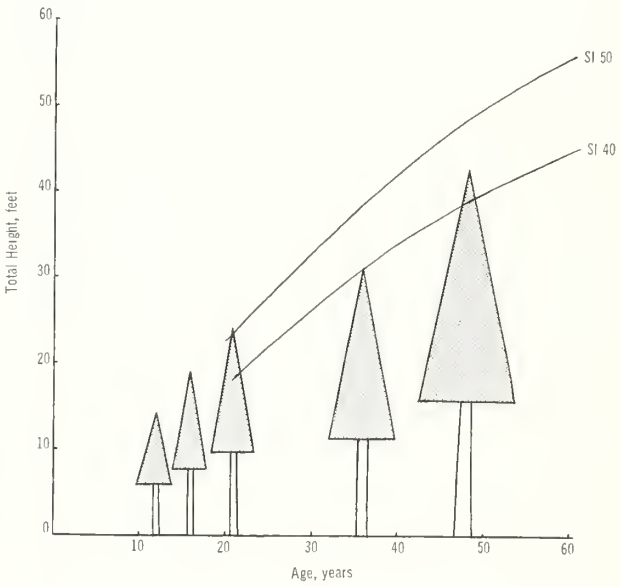


Figure T-5.--Average total heights of dominant and codominant jack pines in a Nebraska Sandhills plantation, in relation to site index curves for jack pine in the Lake States.

Scots pine provenances differ markedly in eastern Nebraska

Scots pine is not only a valuable tree for shelterbelts and ornamental plantings, but is also one of the main species planted for Christmas trees. Trees from 36 seed provenances show marked differences in growth rates and winter foliage color after 4 years in eastern Nebraska. There are only negligible differences in foliage color during the growing season.

Provenances from central France (La Chaise-Dieu in Auvergne) and northwest Turkey (100 miles west of Ankara) grew moderately fast, were free of winter injury, and exhibited the highly desirable dark blue-green foliage color during the winter. These two provenances appear especially desirable for Christmas trees.

The majority of provenances were green to yellow green, and moderate to fast in rate of height growth. The following provenances of fast-growing green appear highly desirable for most planting purposes, including Christmas trees and shelterbelts: Northeastern France (Haguenau in Alsace); southwestern Germany (Landstuhl, 50 miles north of Haguenau); Belgium (150 and 200 miles northwest of Haguenau); and three from northeastern Italy (60 to 90 miles northwest of Venice).

The northernmost provenances were the yellowest. All except a Latvian provenance were slow growers. Although yellow winter coloration is not normally desirable for Christmas trees, they should make highly desirable ornamentals because of the unusual golden color and the slower growth rate, which results in very compact crown form.

Large grades of planting stock outgrow smaller grades

Graded and ungraded ponderosa pine planting stock from two seed sources and three age classes were planted in Nebraska in the spring of 1954. Graded stock consisted of the one-third of the trees that were largest on the basis of stem caliper, top size, and root size. Ungraded stock was bedrun. After 5 years, all classes of graded stock were larger than the ungraded stock from a Niobrara River, Nebraska seed source. There were no significant differences among age classes or sources of graded stock. After 10 years, additional differences had developed. The older (2+1+1) graded Niobrara stock was taller and growing faster than the younger (2+1) graded stock, and the Rosebud, South Dakota stock was taller and growing faster than graded Niobrara stock of similar age class.

Superior growth of the Rosebud stock might be associated with needle volume. Fascicles on Rosebud trees averaged 2.7 needles that aggregated 56 centimeters long; fascicles on Niobrara trees averaged only 2.4 needles that aggregated 43 centimeters long.

Forest Fire

Litter fall heavy after prescribed burning

A prescribed, hot-surface fire consumed 13 and 22 tons of litter per acre on two ponderosa pine plots burned on October 3, 1964. Litter fall the first year after burning amounted to 2.5 and 3.5 tons per acre, 40 to 100 percent more than fell on paired, unburned check plots. The heavy fall was a result of crown scorching. Future litter fall on the burned plots may be less than on the unburned for several years, because length of live crown was reduced on many trees.

Arizona ponderosa pine litter layer dries slowly

A 25-day continuous drying period in late September and early October, 1965 dried the F organic layer under a ponderosa pine stand to only 18 percent, not low enough to burn readily (fig. F-1). The F layer is the "fermenting" layer in which organisms are converting the litter, which is found above, into humus, which is found below. Maximum air temperatures averaged 72°F., minimum air temperatures 37°F. Precipitation of 0.78 inch

on the 26th day raised the moisture content of the F layer back to 189 percent.

These data emphasize the infrequency of conditions suitable for fall burning when the burning prescription requires consumption of the F layer.

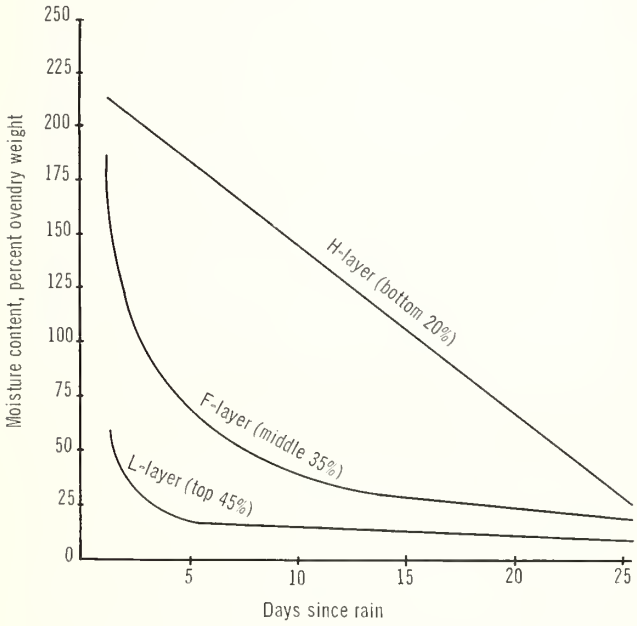


Figure F-1.--Individual curves show the rate of drying at three depths in a 3-inch bed of ponderosa pine litter during an early fall 25-day period.

Winter precipitation influences foliar moisture of Arizona chaparral during regular fire season

Foliar moisture of Arizona chaparral was relatively low during June and early July in 1964, high in 1965. The growing season at the Johnson Wash experimental area was preceded by less than 4 inches of precipitation from December 1, 1963 until visible growth in 1964. The moisture content of shrub live oak foliage rose to about 110 percent, then dropped to less than 80 percent by early June. Spring growth in 1965 was preceded by almost 13 inches of winter precipitation. Foliage moisture rose to more than 175 percent, and remained above 80 percent until August. The critical threshold of flammability is considered to be about 75 percent (fig. F-2).

Figure F-2.--Foliar moisture of Arizona shrub live oak was appreciably higher during June and early July in 1965 than in 1964.

Amount of growth and loss of old leaves seem to account for the difference. During the 1964 growth period about one-third of the oaks grew vigorously and dropped most of the old leaves carried over from preceding years. Another one-third grew slightly and dropped some old leaves. The remainder did not grow and retained the old leaves. During the 1965 season, all oaks grew vigorously and dropped all old leaves.

Precipitation of less than 4 inches may be a danger signal in Arizona chaparral. The serious wildfires in the spring of 1956 were preceded by about 1/2 inch of winter precipitation, according to somewhat scanty records.

Forest Insects

Insect parasites of the spruce budworm inventoried

Thirty-seven species of primary insect parasites have been reared from collections of spruce budworm (Choristoneura fumiferana

(Clem.)) larvae and pupae from central and southern Rocky Mountain outbreaks since 1959. Only seven species are usually "abundant" or "common," and of these, only one is suspected of having caused a major change in population trend.

Bracon politiventris (Cush.) may be the most valuable species, even though it is not always abundant. This small wasp was abundant in some infestations that declined rapidly in 1963. Life history studies are proceeding in the laboratory.

Apanteles fumiferanae Vier. is the most abundant parasite of small budworm larvae, killing 10 to 15 percent in most samples. Glypta fumiferanae Vier., whose habits are similar to those of Apanteles, normally kills about 5 percent of the small larvae. Phaeogenes hariolus (Cress.) (fig. I-1) is an important parasite of the pupae.

Large budworm larvae are attacked by several species of parasitic flies (fig. I-2). Ceromasia auricaudata T. T. is the most important, causing up to 20 percent mortality. Madremyia saundersii (Will.) and Omotoma fumiferanae (Toth.) are also important, killing up to 13 percent and 9 percent, respectively.

Smaller sample unit will increase efficiency of spruce budworm egg mass surveys

A small, 24-inch branch sample was compared with the conventional half-branch sample for estimating egg mass densities at the midcrown of Douglas-fir trees. The egg mass density estimates by each method were similar. The trees usually must be climbed to collect the half-branch sample from midcrown, but the 24-inch branch can be cut from the ground with a pole-pruner (fig. I-3). The lesser amount of foliage on the 24-inch branches also reduces examination time about half.

Egg mass density counts made in August are used for indicating trends of infestations. When the density counts are high and show a decided increase over the previous year, planning may be started for control the following spring.

Diatomaceous earth tested against spruce budworm

A natural deposit of fresh-water diatomaceous earth tested against the spruce bud-

Figure I-1.--Adult female Phaeogenes hariolus (Cress.) lays eggs in spruce budworm pupae. After eggs hatch, the developing wasp kills the budworm pupa. Parasitism may be as high as 20 percent. Little is known of the life history of this important budworm parasite.

Figure I-2.--Each of these budworm larvae bears a white egg of a parasitic fly. Several species of flies lay their eggs on budworm larvae. After the eggs hatch, fly grubs develop inside, eventually killing the budworm pupae.

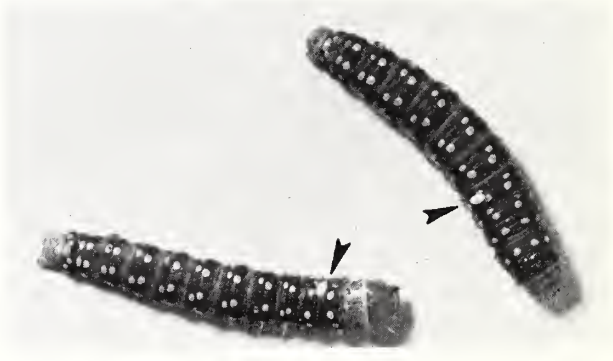


Figure I-3.--Douglas-fir trees are usually climbed to collect mid-crown branches for spruce budworm egg mass counts. Smaller, 24-inch branches can be cut with a pole pruner.

worm. Choristoneura fumiferana (Clem.), showed insecticidal action, but the mortality was not adequate for control.

Time of applications, amount of diatomaceous earth, and percent reduction in budworms were:

1. Just prior to emergence of the overwintering larvae from the hibernaculum (April 14); 30 pounds per acre; 55 percent reduction.
2. When the second-instar larvae were mining in the buds (May 20); 60 pounds per acre; 29 percent reduction.
3. When the third- to fifth-instar larvae were feeding on the needles (June 3); 46 pounds per acre; 12 percent reduction.

In each treatment, 25 small Douglas-fir trees were thoroughly dusted with a hand duster; 25 additional trees were not dusted to serve as checks. No differences could be detected in the degree of defoliation between the treated and untreated trees.

Many kinds of mites found on Black Hills beetle

More than 15 kinds of mites were found on and associated with the Black Hills beetle (Dendroctonus ponderosae Hopkins), often in great numbers (fig. I-4). Several of the species may be predaceous upon the immature stages of the beetle. Others feed on organic matter in the inner bark, and use the beetles for transport hosts. The predaceous species need detailed study to learn their value in regulating bark beetle populations.

Figure I-4.--Phytoseiid mites on the ventral side of a Black Hills beetle.

Caged beetles attract others, aid research

In July 1965, nine cages of beetles (fig. I-5) were fastened to trees in a Black Hills beetle outbreak to attract other emerging beetles and provide properly spaced infestations for further study. The caged beetles made effective attractants. Beetles emerging from 88 trees attacked in 1964, plus other beetles that may have been drawn from greater distances, were attracted to trees surrounding 7 trees under attack by caged beetles. An evaluation prior to beetle emergence indicated a static to increasing infestation.

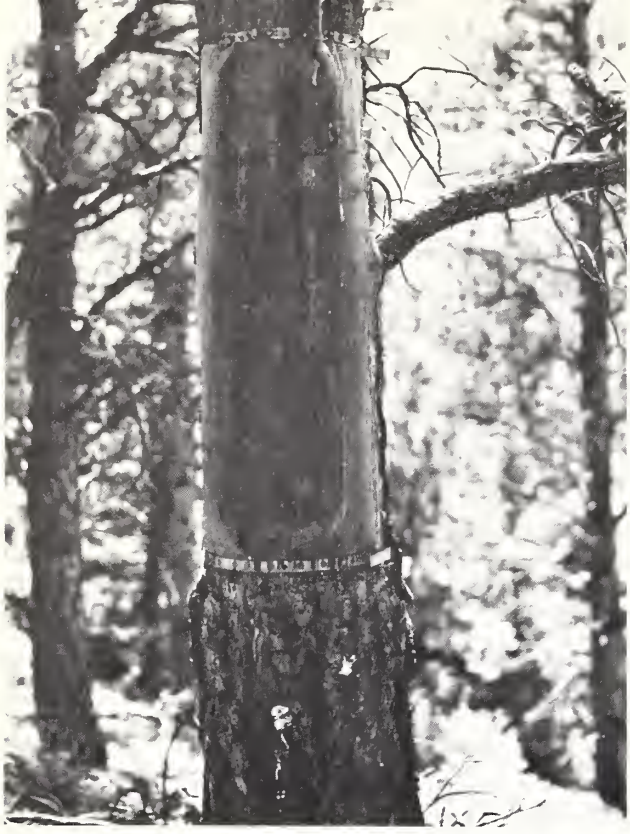


Figure I-5.--Female Black Hills beetles inside this screen cage effectively attract other beetles.

Beetle-predator relationships complicated

A predaceous fly, believed to be Medetera aldrichii (Wheeler) (fig. I-6) was attracted by Black Hills beetles within 20 minutes after the beetles were added to cages on trees. Even as the beetles were entering the tree, the fly was laying eggs in pitch pockets on the exposed bark.

Figure I-6.--Medetera aldrichii Wheeler, an effective predator of Black Hills beetle larvae.

Studies of the red-bellied clerid, Enoclerus sphageus Fabricius, another important enemy of Black Hills beetles, show the larvae (fig. I-7) may be "side-tracked" and destroy broods of an unimportant secondary bark beetle. Observations on these two predators reveal some of the complications of determining the relationships between the Black Hills beetle and its natural enemies.

Figure I-7.--The red-bellied clerid in its pupal chamber in the inner bark. A large number of clerids pupate in the duff at the base of beetle-killed trees.

Black Hills beetle emergence period

The emergence period of the Black Hills beetle is critical, because control must cease during the main emergence and flight to new trees and centers of infestation. In Colorado, the start of emergence from infestations in ponderosa pine may vary about 10 days from year to year, but normally it begins about July 20. Control can effectively continue for another week or so after that date.

Emergence proceeds slowly and erratically for the first 10 to 15 days. During that time approximately 5 percent of the beetles emerge. By the end of August, approximately 90 percent of the beetles have emerged, and few

additional trees will be attacked. The later emergence begins, the more rapidly it proceeds.

Propagation of virus on Great Basin tent caterpillar

An attempt to propagate a native nuclear polyhedrosis virus that is known to cause widespread mortality of the Great Basin tent caterpillar, Malacosoma fragile Stretch, was only partially successful. An aqueous suspension of the virus was applied with a back-pack mist blower to 1 acre of aspen reproduction heavily infested with caterpillars in the fourth and fifth instars. Approximately 450 billion polyhedra were applied in a volume of 8 gallons of water.

Nearly all of the larva were killed by the virus infection within 2 weeks after the treatment. Tents with the dead caterpillars were then collected. The yield of polyhedra containing the virus crystals was low, about 10 times the amount applied.

Recovery of the virus in future propagation tests probably can be increased by modifying the procedures as follows: (1) apply the spray to the foliage in the immediate vicinity of the larval tents only; (2) initiate the virus-recovery collections by the ninth day after spraying to avoid losses from disintegration; (3) apply lower concentrations of the pathogen.

Forest Diseases

Dwarfmistletoe reduces basal area growth of ponderosa pine

The impact of dwarfmistletoe on basal area growth of southwestern ponderosa pine depends on the severity of infection. In the Hawksworth severity rating system, 1 represents light infection and 6 the heaviest infection. The average basal area of uninfected trees and trees with an initial rating of 1 or 2 on sample plots in the Grand Canyon National Park increased during a 10-year period. As the dwarfmistletoe rating increased above 1, however, the average basal area growth decreased rapidly (fig. D-1). The zero growth line was crossed between ratings 2 and 3 as mortality losses began to exceed growth, and trees initially rated as 6 averaged a minus 0.80 square foot of basal area growth per tree. The greatest impact was on trees in the intermediate size classes.

The slightly greater growth noted for lightly infected trees in severity class 1 than for uninfected trees is a common phenomenon. All evidence indicates that this is because the first trees to become infected in a stand are commonly the largest and fastest growing, and not because of any stimulatory effect of light infection. Dwarfmistletoe intensified by about 1 rating point over the 10-year period.

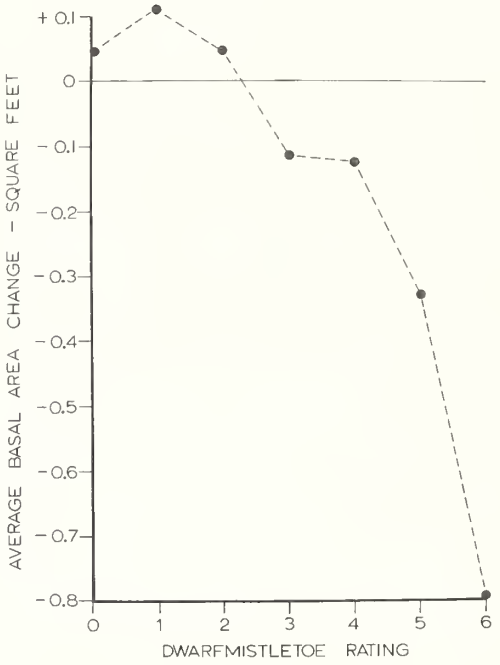


Figure D-1.--Average basal area change in ponderosa pine in relation to the degree of dwarfmistletoe infection.

Dwarfmistletoe seed velocity estimates revised

High-speed photography (fig. D-2) has demonstrated that the initial velocities of seeds of dwarfmistletoes are actually much greater than previously estimated (fig. D-3). Veloc-

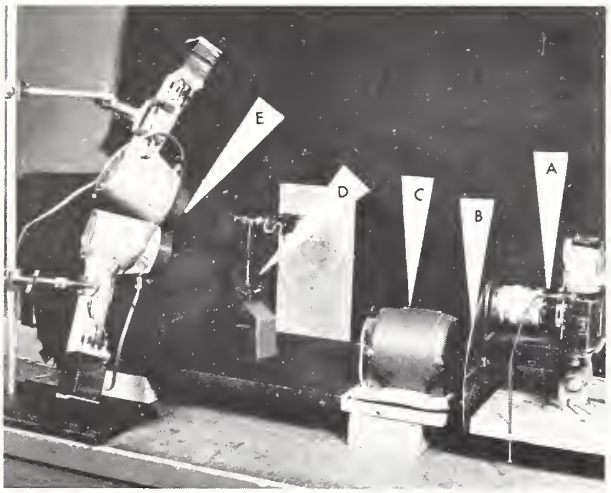


Figure D-2.--Apparatus used for photographic study of dwarfmistletoe seed velocity. A, camera; B, disc with 16 slits; C, motor for rotating disc; D, pendulum on which mature fruit was placed; and E, flash unit.

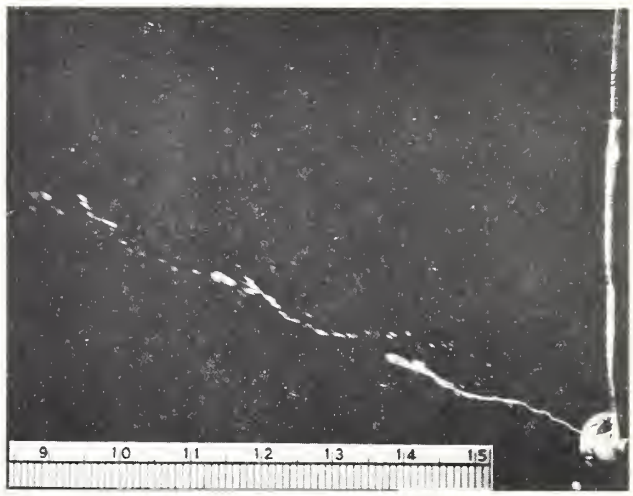


Figure D-3.--Dwarfmistletoe seed in flight. Time interval between exposures was approximately 1/1000 second. Distance traveled by seed between exposures is indicated by millimeter rule. Seeds are blurred because they travel about one-third of their length during slit exposure period of 0.033 second.

ities of seeds of Arceuthobium douglasii Engelm. and A. campylopodum f. cyanocarpum (A. Nels.) Gill were found to average 72 feet per second; seeds of A. vaginatum f. cryptopodum (Engelm.) Gill and A. americanum Nutt. averaged 85 feet per second.

Arceuthobium well represented in Mexico

The Mexican representatives of Arceuthobium have never been studied critically, and A. vaginatum has long been the only species recognized as occurring in Mexico. Recent field and herbarium studies, however, in conjunction with a general taxonomic review of the dwarfmistletoes, indicate that this interpretation of the genus in Mexico is an oversimplification. Instead of a single polymorphic species, A. vaginatum, we now recognize a total of 13 taxa in Mexico, including five dwarfmistletoes common to the United States. These and other observations lend further support to the conclusion that the Sierra Madre Occidental is probably the center of origin for the genus.

Scleroderris canker found on subalpine fir in Colorado

A previously unreported canker of subalpine fir was observed in 1964 and 1965 on several recreational sites on the Laramie River drainage of the Roosevelt National Forest. Laboratory study indicated that the causal fungus of the canker is Scleroderris abieticola Zeller & Gooding, previously described on grand fir and Pacific silver fir. Although 20 percent of the young subalpine fir were attacked, only about 1 percent were killed. The principal damage appears to be highly conspicuous and unsightly dead foliage. Datable cankers suggest that the disease is on the wane, and unless conditions recur which favor its spread, the esthetic value of the recreational areas probably will not be seriously affected.

Southern limits of Hypoxylon canker extended

Hypoxylon pruinatum (Klotzsch) Cke. was collected on quaking aspen west of Big Lake

near the southern edge of Apache County in the Apache National Forest in Arizona. This collection extends the southern known limits of Hypoxylon canker of aspen to within 200 miles of the Mexican border.

Cytospora canker reappears on Pike National Forest

Cytospora kunzei var. kunzei (Sacc.) Waterman. of Douglas-fir was prevalent on the Pike National Forest in Colorado and on adjacent private and State forest lands in the summer of 1964. The affected area of approximately 250 square miles is a few miles west of the 1928 infection center. In the 1964 outbreak, definite cankers were not always formed, but copious resin flow indicated dead cambium beneath the bark. The oldest cankers found were 2 years old. Top and branch killing on large trees were usually limited to the upper bole. Small trees (less than 10 feet high) were completely girdled and killed in 1 or 2 years by the fungus.

Other outbreaks of this canker disease have been associated with drought. At the center of the affected area, accumulated January-July precipitation amounted to 5.02 inches and 6.38 inches in 1963 and 1964, respectively, as compared with an average of 10.33 inches for the same period in the preceding 4 years. Observations are continuing to determine if the current outbreak will recede following the improvement in moisture conditions in 1965.

Aseptic seedlings for mycorrhizal synthesis trials obtained by hydrogen peroxide treatment

Three different seed treatments were used in laboratory tests to obtain aseptic seedlings for mycorrhizal synthesis trials. Hydrogen peroxide, a chemical known to be effective for sterilizing seedcoat surfaces and for stimulating seed germination, was used alone and in combination with soaking or washing seed of juniper, ponderosa, and pinyon pines (fig. D-4). A 30-minute soak in 30-percent hydrogen peroxide reduced fungal and bacterial contamination to a very low level. The highest germination percent occurred in the wash and peroxide combination. This treatment gave significantly higher germination of ponderosa pine and juniper seeds than the peroxide treatment alone.

Figure D-4.--Aseptic seed cultures used in mycorrhizal synthesis trials.

Cedar blight controlled with fungicides

Cedar blight (Phomopsis juniperovora Hahn) is the most damaging disease of eastern redcedar in Plains nurseries. Excellent control of this disease on 1-0 and 2-0 seedlings was obtained with Puratized Agricultural Spray (phenylmercuri triethanol ammonium lactate) in an eastern Nebraska nursery.

The importance of obtaining planting stock free of cedar blight was shown by outplanting Phomopsis-blighted and nonblighted eastern redcedar planting stock. Survival 5 years after planting: blight-free stock, 82 percent; blighted stock, 56 percent.

Dutch elm disease increasing in Nebraska

Dutch elm disease (Ceratocystis ulmi (Buism.) C. Moreau) continues to spread rapidly in Nebraska. The disease was first detected in the State in 1960. It is now known to be present in 27 counties.

Publications

Aldon, Earl F., and Brown, Fletcher J. Jr.*
A prefabricated flume for gaging ephemeral streams. U.S. Forest Serv. Res. Note RM-55, 8 pp., illus.
Describes some of the construction details used on a modified trapezoidal flume built for flashy, ephemeral streams carrying heavy sediment loads. Footings, cinder block walls, prefabricated steel frames, and prefabricated fiberglassed plywood sidewall panels make up the major components of flume.

Alexander, Robert R.
Growth of thinned young lodgepole pine in Colorado. J. Forest. 63: 429-433, illus.
Uniform thinning reserved 630 trees per acre, 8.5 feet apart. Crop-tree thinning released 100 trees per acre, each centered in a 16-foot-diameter clearing. Both stimulated diameter growth. Uniform thinning best meets thinning objectives. Earlier stumpage returns are indicated, and total stand growth will be redistributed on fewer but better quality stems.

Barger, Roland L., and Ffolliott, Peter F.
Specific gravity of alligator juniper in Arizona. U. S. Forest Serv. Res. Note RM-40, 2 pp.
Mean specific gravity, determined from breast-high increment cores, is 0.453 (green volume, ovendry weight). This value indicates a potential charcoal recovery of about 750 pounds per cord, and a wood hardness comparable to eastern redcedar.

Berndt, Herbert W.
Snow accumulation and disappearance in lodgepole pine clearcut blocks in Wyoming. J. Forest. 63: 88-91, illus.
Clearcutting in blocks of 5, 10, and 20 acres increased peak snow accumulation by 2.5 inches, water equivalent. Effect was greatest on east aspects. Greatest influence of block size occurred on south aspects.

Blackstone, J. B.,* Rice, R. W.,* and Johnson, W. M.
A study of the esophageal fistula sampling technique. Proc. West. Sect. Amer. Soc. Anim. Sci. 16: 75-1 to 75-6.
New esophageal techniques have been developed to measure nutritive and digestibility quality of range forage. Moisture, ash, and nitrogen contaminations from saliva were found to be important.

Brown, Harry E.
Characteristics of recession flows from small watersheds in a semiarid region of Arizona. Water Resources Res. 1: 517-522, illus.
Recession flows from eight small watersheds were differentiated on the basis of precipitation and vegetation. Duration of master recession (1-23 hours) depended on season and vegetation.

_____
Preliminary results of cabling Utah juniper, Beaver Creek watershed evaluation project. Ariz. Watershed Symp. Proc. 9: 16-20, illus.
There has been no significant change in water or sediment yield as a result of a cabling and burning treatment on a watershed in the Utah juniper type. Herbage production, primarily forbs and half-shrubs, has increased following treatment.

_____ and Thompson, J. R.
Summer water use by aspen, spruce, and grassland in western Colorado. J. Forest. 63: 756-760, illus.
Although aspen plots used most water annually and grassland plots least for 3 years of record, spring soil moisture was so different among types that differences in water use could not be attributed solely to vegetation type.

_____ and Worley, David P.
Some applications of the canopy camera in forestry. J. Forest. 63: 674-680, illus.
Special wide-angle photographs are used to describe a point on the ground in terms of the vegetation and topography surrounding it. Dot grid counts can be used to describe areal extent and distribution of canopy. With sun path overlays, canopy effects on direct solar radiation can be interpreted, and this canopy-insolation relationship is described in terms of "sunlight factor."

Cable, Dwight R.
Damage to mesquite, Lehmann lovegrass, and black grama by a hot June fire. J. Range Manage. 18: 326-329, illus.
Twenty-five percent of mesquite trees were killed on an area with Lehmann lovegrass ground cover compared to 8 percent on an area with black grama. Ninety percent of black grama plants and more than 98 percent of lovegrass plants were killed. Many new lovegrass seedlings became established on both areas.

Campbell, Ralph E.
A tool for removing neutron probe access tubes from the soil. Soil Sci. Amer. Proc. 29: 761-762, illus.
Tool which is described consists of a tapered shaft jacketed in a split sleeve with matching taper. As the shaft is pulled, it slips in the sleeve, causing the sleeve to expand against the inner wall of the access tube. Friction between the sleeve and the tube wall holds the puller in place as the tube is drawn from the soil.

Clary, Warren P.
Temperature effects on reproductive processes of Russian wildrye. Agron. J. 57: 4-6, illus.
Temperature treatment from -1° to 21°C. during anther emergence caused various floral injuries. Freezing injured anthers; high temperatures, pistillar tissue.

Currie, Pat O., and Hammer, F. L.
An improved gate fastener for range fences. J. Range Manage. 18: 98, illus.
Describes construction and attachment of an inexpensive gate fastener used successfully for over 15 years. It has reduced livestock straying and fence maintenance by having tight but easy-to-close gates.

Davis, Edwin A.
The mechanism of fenuron injury to plants. U. S. Forest Serv. Res. Note RM-50, 2 pp.
Although starvation is the ultimate cause of death, the direct cause of leaf injury may be a toxic accumulation product in the blocked photosynthetic mechanism. At high concentrations, fenuron also inhibits root growth.

*Private, State, or Federal cooperator.

Davis, James R.

A survey of an intentional burn in Arizona ponderosa pine. U.S. Forest Serv. Res. Note RM-41, 2 pp.

Two-thirds of the burnable area burned, mostly with a light surface fire. Understory release and damage were low, commensurate with the overall low-intensity fire.

Dietz, Donald R.

Deer nutrition research in range management. N. Amer. Wildlife and Natur. Resource Conf. Trans. 30: 274-285.

Reviews literature on nutritional terms, techniques, and the application of nutritional information to the management of game ranges. Reviews the results of nutritional studies on deer ranges in Colorado covering a 6-year period. Includes proximate chemical analyses of major deer forage species on both summer and winter ranges, and gives results of digestibility trials on the three important winter deer browses.

Ffolliott, Peter F.

Determining growth of ponderosa pine in Arizona by stand projection. U. S. Forest Serv. Res. Note RM-52, 4 pp., illus.

Describes a system of determining growth rates from one sampling of a forest.

_____

A multiple BAF angle gage. U. S. Forest Serv. Res. Note RM-43, 2 pp., illus.

Different basal area factors (BAF's) can be used in point sampling by mounting crossarms of known widths on a rod of known length. The crossarm swings freely when the rod is inclined, automatically compensating for slope.

_____ and Barger, Roland L.

A method of evaluating multiproduct potential in standing timber. U. S. Forest Serv. Res. Paper RM-15, 24 pp., illus.

Method described will: (1) remove observer bias from stand quality inventory (2) provide a record of frequency of occurrence of stem features that affect product quality and yield; (3) characterize and quantify suitability of the timber resource for a broad range of products; (4) provide adequate multiproduct quality and yield information for management and utilization decisions; and (5) provide a continuing basis for such decisions through time.

_____, Hansen, Edward A., and Zander, Almer D.*

Snow in natural openings and adjacent ponderosa pine stands on the Beaver Creek watersheds. U. S. Forest Serv., Res. Note RM-53, 8 pp., illus.

A sapling and pole stand held most snow just prior to spring runoff, and had a high melt rate. Snow was held in a "zone of retention" in openings throughout the winter out to distances of 1-1/2 to 2H (H= average height of adjacent timber), regardless of tree height or stocking conditions.

_____ and Worley, David P.

An inventory system for multiple use evaluations. U. S. Forest Serv. Res. Paper RM-17, 15 pp., illus.

Describes a multiple BAF (basal area factor) inventory system flexible enough to describe a forested tract so multiple use interpretations can be made from known relations of product yields to the inventory description of the resources on the tract. Its use is illustrated by hypothesizing forest management methods for a pilot watershed in Arizona.

Gary, Howard L.

Some site relations in three flood-plain communities in central Arizona. Ariz. Acad. Sci. J. 3: 209-212, illus.

The relationships of ground-water depths to soil textures and conductivities in the first 3 feet of alluvium were studied in flood-plain communities of tamarisk, arrowweed, and mesquite along the Salt River.

_____ and Campbell, C. J.

Water-table characteristics under tamarisk in Arizona. U. S. Forest Serv. Res. Note RM-58, 7 pp., illus.

Water-table fluctuations in 39 ground-water wells within a circular area of about 40 feet in diameter are discussed before and after vegetation removal. Pumping tests to simulate natural diurnal fluctuations in selected wells were not satisfactory. Evapo-transpiration (ET) losses were not determined.

_____ and Horton, Jerome S.

Some sprouting characteristics of five-stamen tamarisk. U. S. Forest Serv. Res. Note RM-39, 7 pp., illus.

The drying of cuttings reduced sprouting ability, and no sprouting occurred after moisture losses of 45 percent. Results indicate control operations should be done during periods when soil is dry and weather warm.

Goodell, B. C.

Water management in the lodgepole pine type. Soc. Amer. Forest. Proc. 1964: 117-119.

The application of more intensive silviculture to the lodgepole pine type should benefit water production as well as wood production. Measures to increase the former are, to a high degree, compatible with those to accelerate the latter.

Hamilton, Martin A.

Multiple comparison procedures. U. S. Forest Serv. Res. Note RM-44, 12 pp.

Provides a foundation on which different local comparison methods may be presented. Describes and compares well-known procedures. Examples are given illustrating different test methods. Suggestions for selecting appropriate tests for a particular problem are presented.

Hawksworth, Frank G.

Arceuthobium douglasii in Nevada and Wyoming. Madrono 18: 63.

First reports of the Douglas-fir dwarfmistletoe in these two States.

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Diseases of lodgepole pine. Soc. Amer. Forest. Proc. 1964: 125-127.

Summarizes the diseases of lodgepole pine and describes control measures for those currently considered to be most serious -- dwarfmistletoe, comandra rust, and atropellis canker.

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Life tables for two species of dwarfmistletoe. I. Seed dispersal, interception, and movement. Forest Sci. 11: 142-151, illus.

About 38 percent of Arceuthobium americanum and 44 percent of A. vaginatum seeds were caught by trees, mostly on needles. Rain was a significant factor in necessary movement of seeds from needles to twigs. Of total seeds produced, 14 percent of A. americanum and 6 percent of A. vaginatum germinated on twigs.

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Notes on Arceuthobium on bristlecone pine. Leafl. West. Bot. 10: 163-164.

The principal mistletoe on bristlecone pine is A. campylopodum f. cyanocarpum, the limber pine

dwarfmistletoe. Two others recorded for the first time on this host are A. vaginatum f. cryptopodum and A. americanum.

_____ and Hinds, Thomas E.

Spread of a parasite. Natur. Hist. 74(3): 52-58, illus.

A semipopular, illustrated account of the dwarfmistletoes (Arceuthobium spp.). Emphasizes the seriousness of the dwarfmistletoes as forest disease agents, and discusses their biology and methods of control.

_____ and Wiens, Delbert.*

Arceuthobium in Mexico. Brittonia 17: 213-238.

Gives results of a taxonomic study of the dwarfmistletoes in Mexico. Thirteen members of the genus Arceuthobium are recognized from Mexico, including five that occur in the southwestern United States. Three new species and two new subspecies are described.

Heede, Burchard H.

Hydraulic reclamation--a unique Italian method in watershed rehabilitation. J. Soil & Water Conserv. 20: 216-219, illus.

Erosive action of concentrated flow is used, instead of resisted, to stabilize a watershed in a three-phase treatment: (1) runoff concentrated in ditches breaks down sharp ridges in highly eroded soft shale soil; (2) areas not reached by water are rounded mechanically; and (3) rounded slopes are tilled, fertilized, planted.

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Multipurpose prefabricated concrete check dam. U. S. Forest Serv. Res. Paper RM-12, 16 pp., illus.

The dam consists of nine major parts: six prestressed wall slabs of conventional concrete, and three buttress-footing units of lightweight reinforced concrete. It can be placed in 3 hours (except for excavation and backfill) with two laborers and a backhoe.

Hinds, Thomas E., and Hawksworth, Frank G.

Seed dispersal velocity in four dwarfmistletoes. Science 148(3669): 517-519, illus.

High-speed photos showed initial seed velocities of Arceuthobium douglasii and A. campylopodum f. cyanocarpum averaged 2,200 cm./sec. (72 ft./sec.), significantly lower than the 2,600 cm./sec. (86 ft./sec.) average for A. vaginatum f. cryptopodum and A. americanum.

_____, Hawksworth, Frank G., and Davidson, Ross W.*

Beetle-killed Engelmann spruce: its deterioration in Colorado. J. Forest. 63: 536-542, illus.

Some 4.3 billion board feet of sawtimber was killed by the Engelmann spruce beetle in Colorado from 1941 to 1952. About 40 percent of it has been lost: one-third to decay in standing trees, two-thirds to windthrow. Windthrow losses will probably become progressively more important.

_____ and Jones, John R.

Hypoxylon canker of aspen in Arizona. U.S. Agr. Res. Serv. Plant Dis. Rpt. 49:480, illus.

A typical canker was collected on the Apache National Forest in 1964. Two earlier observations (1957, 1962) were not supported by herbarium specimens.

_____ and Stewart, James L.*

Cytospora canker recurrence on Douglas-fir in Colorado. U. S. Agr. Res. Serv. Plant Dis. Rpt. 49: 481-482.

A 1964 outbreak, a few miles from a 1928 outbreak, is evidently the result of an endemic parasite becoming epidemic under environmental conditions unfavorable to the host.

Hutchison, Boyd A.

Snow accumulation and disappearance influenced by big sagebrush. U. S. Forest Serv. Res. Note RM-46, 7 pp., illus.

Significantly more snow accumulated on sagebrush plots than on comparable grass plots. Continuous ice sheets, present during much of the snowmelt period on grass plots, were not observed under sagebrush. Melt rates were similar in both types, but sagebrush retained snow longest because of its greater accumulation.

Jameson, Donald A.

Arrangement and growth of pinyon and one-seed juniper trees. Plateau 37: 121-127, illus.

Trees grew in three patterns: singly, in groups of trees of about equal size, and small trees as understory to larger trees. Large trees apparently were more important for shade than for seed. Small trees grew fastest; pinyon faster than juniper.

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Phenology of grasses of the northern Arizona pinyon-juniper type. U. S. Forest Serv. Res. Note RM-47, 8 pp., illus.

Cool-season grasses reached peak height between May 18-June 21, and remained partly green all year. Warm-season grasses reached peak height between September 11-21, were green only during spring, summer, and fall. Cool-season grasses usually need more protection.

_____ and Reid, Elbert H.

The pinyon-juniper type of Arizona. J. Range Manage. 18: 152-153, illus.

Summarizes information on the pinyon-juniper type, including effects on forage production and methods of tree control, contained in U.S. Dep. Agr. Prod. Res. Rep. 84 of the same title.

Johnson, W. M.

Field key to the sedges of Wyoming. Wyo. Agr. Exp. Sta. Bull. 419, 239 pp., illus.

Illustrates and describes 101 sedges, Carex and Kobresia, with emphasis on vegetative features.

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Formula for a sheepherder. Wyo. Wool Grower 38(8): 9, illus.

A statistical expression called the Standard Deviation was used to evaluate three herders. The best herder maintained a loose, slow-moving band to get most nearly uniform herbage utilization.

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Rotation, rest-rotation, and season-long grazing on a mountain range in Wyoming. U. S. Forest Serv. Res. Paper RM-14, 16 pp., illus.

Rotation and rest-rotation were superior to season-long grazing. Plant cover increased under rest-rotation, and was maintained on an overstocked allotment under rotation grazing. Range deteriorated under season-long grazing. Herbage utilization was reduced under both rest-rotation and rotation without reducing livestock numbers.

_____, Blankenship, J. O.,* and Brown, G. R.

Explorations in the germination of sedges. U. S. Forest Serv. Res. Note RM-51, 8 pp., illus.

Germination of sedge seed varies widely among species. Effects of seed treatments varied similarly. Light seems to be necessary, and short (7-day) cold treatment was usually beneficial. Chemical treatments gave highly variable, sometimes conflicting, results.

Judd, B. Ira. *
Oak forage plants on Arizona ranges. Ariz. Cattlelog 22(9): 12-13, illus.
Gives botanical description of shrub live oak and Gambel oak, and their value on livestock ranges. (Information taken from Rocky Mountain Station Sta. Paper 69, published in 1962.)

Judson, Arthur.
The weather and climate of a high mountain pass in the Colorado Rockies. U.S. Forest Serv. Res. Paper RM-16, 28 pp., illus.
Presents information basic to mountain meteorology and avalanche-control planning from Berthoud Pass--an area representative of Colorado's avalanche zones near timberline. Describes and illustrates wind, temperature, snowfall, snow depth, rainfall, and related weather patterns from data collected irregularly 1926-49, continuously since then. Compares direction and windspeeds at surface at Berthoud Pass with 4,000 meter winds over Denver and Grand Junction. Analyzes weather relationships of 10 large winter storms at the Pass.

Kelso, M. M.,* and Mack, Lawrence.*
The value of additional surface water to agriculture in the Salt River Project. In Wealth from Watersheds. Ariz. Watershed Symp. Proc. 8: 40-47, illus.
Assuming no changes in technology or arrangements for distribution, additional water delivered to the area should be worth from $10.80 per acre-foot at a 4-percent discount rate for water (which will increase annual supply for the area to between 3.5 to 4 feet) to $2.11 per acre-foot at an 8-percent discount rate (which will increase supply to between 5.0 to 5.5 feet).

Lightle, Paul C., and Hawksworth, Frank G.
New hosts for broom-causing fungi in the Southwest. U.S. Agr, Res. Serv. Plant Dis. Rpt. 49: 417-418, illus.
Microstroma juglandis on Juglans microcarpa and Articularia quercina var. minor on Quercus dunnii are recorded for the first time on these hosts.

McCulloch, C. Y.,* Wallmo, O. C., and Ffolliott, P. F.
Acorn yield of Gambel oak in northern Arizona, U. S. Forest Serv. Res. Note RM-48, 2 pp., illus.
Acorn production was highest among trees of 12-14 inches d.b.h. with over 80 percent of live crown. Beyond 14 inches yield fell abruptly. Trees with less than 80 percent of live crown produced relatively few acorns regardless of size.

McEwen, Lowell C., and Dietz, Donald R.
Shade effects on chemical composition of herbage in the Black Hills. J. Range Manage. 18: 184-190, illus.
Kentucky bluegrass and some associated species contained more nitrogen-free extract and less crude fiber, calcium, and phosphorus when growing on open meadow sites than on pine-shaded sites. During early development, plants on soils from limestone had more crude protein than plants on soils from metamorphic parent materials.

Martin, E. C.
Growth and change in structure of an aspen stand after a harvest cutting, U. S. Forest Serv. Res. Note RM-45, 2 pp., illus.
Annual increment over a 20-year period on a small plot was 84 cubic feet per acre. Larger trees were more vigorous and grew better.

Martin, S. Clark.
Some changes in brush since 1949. Ariz. Cattlelog 21(5): 24, 26, 30, illus.
Although both burning and bulldozing have helped reduce mesquite and burroweed, records since 1949 indicate that brush control is a continuing fight; that programs must be fitted not only to the kind of brush, but also to the situation where it is found.

Martinelli, M. Jr.
Accumulation of snow in alpine areas of central Colorado and means of influencing it. J. Glaciol. 5: 625-636, illus.
Based on data collected from 1958 through 1963 on six test sites, at three sites the fences increased snow depths appreciably, and snowfields persisted longer than usual. At the other three, snow depths were increased close behind the fences but were decreased farther downwind with no net increase in amount of snow caught.

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An estimate of runoff from alpine snowfields. J. Soil & Water Conserv. 20: 24-26, illus.
Snow density and vertical ablation data indicated the snowfields in an alpine area of about 57,000 acres had a water yield potential of 32,000 acre-feet of water per acre of snow present on June 23, 1956, or about 6 acre-inches of water per acre of alpine.

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Influence of gap width below a vertical slat snow fence on size and location of lee drift. Int. Ass. Sci. Hydrol. Bull. 9(4): 48-57, illus.
A 1-foot gap below a 6-foot vertical-slat snow fence gave maximum snow depth and volume in the lee drift. Gaps of 2 and 4 feet moved maximum depth further from the fence, and cut volume almost in half.

Meiman, James R.,* and Horton, Jerome S.
Watershed management research from desert to alpine. Soc. Amer. Forest. Proc. 1964: 93-96.
Characterizes the diversity of approaches and interests in selected studies that deal with specific ecologic zones.

Neff, D. J.,* Wallmo, O. C., and Morrison, D. C.*
A determination of defecation rate for elk. J. Wildlife Manage. 29: 406-407.
An elk (Cervus canadensis) pellet-group count was carried out on June 5, 1964, in the 217-acre Flagstaff Buffalo Park. Four to 10 animals on native forage over a 4-month period deposited an estimated 12.52 pellet groups per elk per day.

Pase, Charles P.
Shrub seedling regeneration after controlled burning and herbicidal treatment of dense Pringle manzanita chaparral. U.S. Forest Serv. Res. Note RM-56, 2 pp., illus.
Planned fall burning of dense manzanita chaparral was followed by large increases in seedlings of yerba-santa, Pringle manzanita, desert ceanothus, and five other shrub species. Seedlings of most shrub species were virtually absent from an adjacent unburned area, and from an area sprayed with 2,4-D but not burned.

_____ and Glendening, George E.
Reduction of litter and shrub crowns by planned fall burning of oak-mountainmahogany chaparral. U.S. Forest Serv. Res. Note RM-49, 2 pp., illus.
Shrubs were dried prior to burning by spraying with Dinoxol (butoxy ethanol esters of 2,4-D and 2,4,5-T). Litter reduction varied from one-third to one-half; shrub canopy was reduced over 90 percent.

_____ and Ingebo, P. A.
Burned chaparral to grass: Early effects on water and sediment yields from two granitic soil watersheds in Arizona. Ariz. Watershed Symp. Proc. 9: 8-11, illus.
Annual spraying with 2,4,5-T following a wildfire in chaparral successfully held resprouting brush cover to less than 10 percent crown density and allowed establishment of a good grass cover. Compared to an adjacent watershed returning to brush cover, water yields increased significantly. Sediment yields increased immediately after the fire, and declined to near pre-fire levels within 5 years.

Pearson, Henry A.
Low-cost constant-temperature water bath. J. Range Manage. 18: 149-151, illus.
Describes a device used in artificial-rumen (in vitro) digestion studies. The bath costs less than $65, accommodates over 250 digestion tubes of 100 ml. capacity.

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Rumen organisms in white-tailed deer from south Texas. J. Wildlife Manage. 29: 493-496, illus.
Only one genus of ciliate protozoa but many genera or morphological types of bacteria were observed. Bacteria were similar to those in domestic ruminants. Protozoa increased during rapid vegetation growth in spring; bacteria showed no seasonal pattern.

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Studies of forage digestibility under ponderosa pine stands. Soc. Amer. Forest. Proc. 1964: 71-73, illus.
Timber; herbage production, utilization, and digestibility; and cattle gains on ponderosa pine ranges are being compared by studying the responses of these factors on thinned forested ranges.

Peterson, Glenn W.
Dothistroma needle blight of Austrian pine: infection and control. U.S. Agr. Res. Serv. Plant Dis. Rpt. 49: 124-126.
Tests of fungicides at Lincoln, Nebraska, showed Bordeaux mixture gave good control. Also, D. pini was found to affect previous seasons' needles as well as current growth.

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Field survival and growth of Phomopsis-blighted and non-blighted eastern redcedar planting stock. U.S. Agr. Res. Serv. Plant Dis. Rpt. 49: 121-123.
Survival of non-blighted stock was higher at the end of each of five growing seasons, although height and stem diameter of surviving trees was not different. Stock, even if slightly damaged by the fungus, should not be outplanted.

_____, Sumner, D. R.,* and Norman, C.*
Control of Phomopsis blight of eastern redcedar seedlings. U.S. Agr. Res. Serv. Plant Dis. Rpt. 49: 529-531, illus.
Puratized Agricultural Spray (PAS) at three rates controlled Phomopsis blight on 1- and 2-year-old seedlings in an eastern Nebraska nursery. Spreader-stickers did not improve control. Four other fungicides were not satisfactory.

_____ and Wysong, David S.*
Dutch elm disease spread and control in Nebraska. Nebr. Agr. Exp. Sta. Quart. 11(4): 15-16, illus.
The disease has now killed elms in 14 southeastern counties. Sanitation and application of insecticide are essential parts of a control program once the fungus has been found.

Pissot, Henry J.*
New Mexico's forest area and timber volume. U.S. Forest Serv. Res. Note INT-32, 4 pp.
One-third of New Mexico's 18 million acres of forest land is classed as commercial, of which 69 percent is publicly administered, 55 percent in National Forests. Ponderosa pine occupies 69 percent of the commercial timber-growing area and accounts for more than half of the growing stock and sawtimber volume.

Pond, Floyd W., Lillie, D. T.,* and Holbo, H. R.
Shrub live oak control by root plowing. U.S. Forest Serv. Res. Note RM-38, 2 pp., illus.
Root plowing is one of the more effective ways to kill shrub live oak and promote grass production. Careful attention to details of the root-plowing job improves the kill of shrubs.

Read, Ralph A.
Windbreaks for the Central Great Plains. U.S. Forest Serv., Rocky Mountain Forest and Range Exp. Sta., Unnumbered.
A series of seven how-to-do-it leaflets that describe the design, planting, and management of tree-shrub windbreaks:
1. How to use trees to protect land and crops.
2. How to select tree and shrub species.
3. How to arrange and space trees and shrubs.
4. How to prepare land and plant trees.
5. How to maintain new tree plantings.
6. How to protect them from damage.
7. How to manage established plantings.--(David F. Van Haverbeke, junior author).

Reid, Elbert H.
Forage production in ponderosa pine forests. Soc. Amer. Forest. Proc. 1964: 61-64, illus.
Average forest grazing capacity is about 6 acres per animal-unit month for domestic livestock. Grazing values, determined by how the tree overstory is managed, may vary from zero to $9 or more per acre per year.

Reynolds, Hudson G.
Mule deer killed by lightening. J. Mammalogy 46: 676.
A mule deer doe and two fawns were found electrocuted--a mortality factor of rare occurrence.

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Some livestock wildlife habitat relations in Arizona and New Mexico. Amer. Soc. Range Manage., N. Mex. Sect. Proc. 1964, 13 pp.
Forest openings, important for deer, elk, and cattle, might be created in coordination with timber management for best overall land use. Reduction of tree overstory improves habitat for deer and elk where shrub and other forage production is increased without destroying escape cover.

Rich, Lowell R.
Water yields resulting from treatment applied to mixed conifer watersheds. Ariz. Watershed Symp. Proc. 9: 12-15, illus.
Results from two studies suggest that even-aged management with clearcut openings is a possible way of both maintaining timber supply and increasing water yields. A timber harvest of this type was initiated on the West Fork of Castle Creek in June 1965.

Sander, D. H.
Height growth characteristics of Siberian elm growing in windbreaks in the central Great Plains. U.S. Forest Serv. Res. Note RM-59, 4 pp., illus.
Height-age data, collected by stem analysis techniques, indicated that the height-age curves differed, depending on general soil characteristics and the geographical area sampled.

Shupe, Dorothy G.*
Arizona's forest area and timber volume. U.S. Forest Serv. Res. Note INT-33, 4 pp.
Arizona's 21 million acres of forest land includes only 4 million acres classed as commercial. Of this area, 96 percent is publicly administered, 66 percent in National Forests. The ponderosa pine type, which occupies 92 percent of the commercial forest area, accounts for 85 percent of growing stock and sawtimber volume.

Smith, Dixie R., and Johnson, W. M.
Vegetation characteristics on a high altitude sheep range in Wyoming. Wyo. Agr. Exp. Sta. Bull. 430, 14 pp., illus.
Leaf elongation may be 30 to 50 percent complete before snowmelt, and is over by mid-July. Flowering extends from late June to late August. Soil moisture and snowpack conditions are more important than vegetative growth in determining initial grazing dates.

Spencer, John S. Jr.,* and Farrenkopf, Thomas O.*
Timber products output in Colorado, Wyoming, and western South Dakota, 1962. U.S. Forest Serv. Res. Paper INT-14, 18 pp., illus.
In 1962, Colorado output totaled 36.4 million cubic feet of roundwood products including nearly 185 million board feet saw logs; Wyoming totaled nearly 21 million cubic feet and 117 million board feet; western South Dakota totaled 11.2 million cubic feet and 39 million board feet. Most timber came from National Forests.

Springfield, H. W.
Adaptability of forage species for pinyon-juniper sites in New Mexico. U.S. Forest Serv. Res. Note RM-57, 4 pp.
Gives adaptability ratings (1-10) for 40 species of grass, 2 forbs, and 1 shrub, at 5 pinyon-juniper sites. Plots were seeded in 1946-48; evaluated until 1962. Eleven species warrant special consideration.

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Rate and spacing in seeding crested wheatgrass in New Mexico. U.S. Forest Serv. Res. Note RM-42, 8 pp., illus.
The seeded stands reached an equilibrium with the environment within 5 to 8 years regardless of seeding rate or row spacing. No trend was found toward higher yield with wider spacing during drought. Plant cover in the eighth year was practically the same for the different rates and spacings.

Staley, John M.
Scleroderris canker of subalpine fir in Colorado. U.S. Agr. Res. Serv. Plant Dis. Rept. 49: 882.
Over 20 percent of young subalpine fir in a recreational area were attacked by Scleroderris abieticola, previously unreported in Colorado. Although an apparently strong pathogen, number of active cankers is decreasing.

Stelzer, M. J.
Susceptibility of the Great Basin tent caterpillar, Malacosoma fragile (Stretch), to a nuclear polyhedrosis virus and Bacillus thuringiensis Berliner. J. Invertebrate Pathol. 7: 122-125.
In a field test of the virus, the bacteria, and a combination of the two pathogens, at several dosage levels against larvae of the tent caterpillar in New Mexico, all treatments were capable of causing lethal infection. A combination of the two was most effective.

Van Haverbeke, David F.
"First-aid" for your shelterbelt. Nebr. Agr. Exp. Quart. 12(2): 17-18, illus.
Methods used apply to replacing dead or absent rows of trees, and to narrowing or converting deciduous rows to conifer rows.

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Site preparation in renovating shelterbelts. U.S. Forest Serv. Tree Planters' Notes 1965(73): 3-7, illus.
Four rows of trees were removed from a 10-row, 23-year-old shelterbelt. Stumps were sprayed with 2,4,5-T to prevent resprouting, and a 2-bottom plow was used to break up the compacted soil between stump rows. Plowed strips were left bare overwinter, then replanted between rows of stumps. Work was done during 'slack' time with ordinary farm equipment and a minimum of help.

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Taxonomic aspects of juniper in Nebraska (abstract). Nebr. Acad. Sci. Proc. 75: 11-12.
Analysis of foliage and seed characters showed two aborescent species: Juniperus virginiana L. in the eastern two-thirds, and J. scopulorum Sargent in the western portion of the State. J. scopulorum may influence the juniper population throughout Nebraska, along easterly flowing river drainages.

Wilson, Alvin K.*
Timber products output in Arizona and New Mexico, 1962. U.S. Forest Serv. Res. Paper INT-15, 8 pp., illus.
Output of roundwood products in Arizona in 1962 totaled 65.5 million cubic feet, 76 percent, in saw logs. Pulpwood production started in 1961 and by 1962 amounted to 88,000 cords. New Mexico totaled 46.3 million cubic feet in 1962, 78 percent in saw logs.

Worley, David P.
The Beaver Creek pilot watershed for evaluating multiple use effects of watershed treatments. U.S. Forest Serv. Res. Paper RM-13, 12 pp., illus.
Pilot watershed treatments to increase streamflow are being evaluated in central Arizona to determine multiple use effects on the major forest resources. Methods are being developed for predicting watershed treatment outcomes, so before-and-after product mixes can be estimated for similar areas.

_____ and Miller, Robert L.
A procedure for upstream watershed economic evaluation. In Wealth from Watersheds. Ariz. Watershed Symp. Proc. 8: 36-39, illus.
The general approach is to (1) research ways and means, (2) evaluate these on pilot test areas, (3) extend results to estimate the outcome on a river basin, (4) develop economic background about the basin, and (5) estimate the benefits and costs of instituting the program on the basin.

_____, Mundell, Gerald L.,* and Williamson, Robert M.*
Gross job time studies--an efficient method for analyzing forestry costs. U.S. Forest Serv. Res. Note RM-54, 8 pp., illus.
Input-output data are collected in physical terms--labor time, equipment time, materials, acres treated, trees thinned, et cetera. Production costs are determined by multiplying inputs by dollar rates or costs. Methods of summarizing and analyzing the data, and of applying the results, are illustrated.

Wysong, David S.,* and Peterson, Glenn W.
Oak wilt in Nebraska. U.S. Agr. Res. Serv. Plant Dis. Rpt. 49: 269.
Ceratocystis fagacearum was isolated in July 1964 from red oaks showing characteristic wilt symptoms west of Omaha. Oak wilt was first found in Richardson County in 1950.

COMMON AND BOTANICAL NAMES OF ANIMALS AND PLANTS MENTIONED

ANIMALS

Mammals

Deer, mule	*Odocoileus hemionus hemionus* (Rafinesque)
Deer, white-tailed (Arizona)	*Odocoileus virginianus couesi* (Coues and Yarrow)
Deer, white-tailed (Dakota)	*Odocoileus virginianus dacotensis* Goldman & Kellogg
Elk	*Cervus canadensis canadensis* (Erxleben) Reynolds
Gophers, mountain pocket	*Thomomys talpoides* (Richardson)
Mice, deer	*Peromyscus maniculatus* (Wagner)
Voles, montane	*Microtus montanus* (Peale)

Birds

Grouse, sharp-tailed	*Pedioecetes phasianellus jamesi* Lincoln
Prairie chicken, greater	*Tympanuchus cupido pinnatus* (Brewster)
Turkey, wild	*Meleagris gallopavo merriami* Nelson

PLANTS

Cereals

Oats	*Avena sativa* L.

Forbs

Avens, alpine	*Geum rossii* (R. Br.) Ser.
Birdbeak	*Cordylanthus* spp.
Buckwheat	*Eriogonum* spp.
Geranium, Fremont	*Geranium fremontii* Torr.
Goldeneye	*Viguiera* spp.
Penstemon, toadflax	*Penstemon linarioides* A. Gray
Sweetclover, yellow-blossom	*Melilotus officinales* (L.) Lam.
Wormwood, Louisiana	*Artemisia ludoviciana* Nutt.

Grasses

Bluegrass, Kentucky	*Poa pratensis* L.
Bluegrass, mutton	*Poa fendleriana* (Steud.) Vasey
Brome(s)	*Bromus* spp.
Brome, smooth	*Bromus inermis* Leyss.
Dropseed, black	*Sporobolus interruptus* Vasey
Dropseed, pine	*Elephantopeuron tricholepis* (Torr.) Nash
Fescue, Arizona	*Festuca arizonica* Vasey
Fescue, Thurber	*Festuca thurberi* Vasey
Grama, blue	*Bouteloua gracilis* (H.B.K.) Lag.
Grama, side-oats	*Bouteloua curtipendula* (Michx.) Torr.
Junegrass, prairie	*Koeleria cristata* (L.) Pers.
Lovegrass, Lehmann	*Eragrostis lehmanniana* Nees
Muhly, mountain	*Muhlenbergia montana* (Nutt.) Hitchc.
Muhly, spike	*Muhlenbergia wrightii* Vasey
Needlegrass, green	*Stipa viridula* Trin.
Sedges	*Carex* spp.
Squirreltail, bottlebrush	*Sitanion hystrix* (Nutt.) J. G. Smith
Wheatgrass, crested	*Agropyron cristatum* (L.) Gaertn.
Wheatgrass, intermediate	*Agropyron intermedium* (Host) Beauv.
Wheatgrass, western	*Agropyron smithii* Rydb.
Wildrye, Russian	*Salix* spp.

Shrubs and Trees

Aspen, quaking	*Populus tremuloides* Michx.
Chokecherry	*Prunus virginiana* L.
Cercocarpus, birchleaf	*Cercocarpus betuloides* Nutt.
Cypress, Arizona	*Cupressus arizonica* Greene
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Fir, grand	*Abies grandis* (Dougl.) Lindl.
Fir, Pacific silver	*Abies amabilis* (Dougl.) Forbes
Fir, subalpine	*Abies lasiocarpa* (Hook.) Nutt.
Juniper, alligator	*Juniperus deppeana* Steud.
Juniper, Rocky Mountain	*Juniperus scopulorum* Sarg.
Juniper, Utah	*Juniperus osteosperma* (Torr.) Little
Mesquite, velvet	*Prosopis juliflora* var. *velutina* (Woot.) Sarg.
Oak, Gambel	*Quercus gambelii* Nutt.
Oak, shrub live	*Quercus turbinella* Greene
Pine, jack	*Pinus banksiana* Lamb.
Pine, lodgepole	*Pinus contorta* Dougl.
Pine, pinyon	*Pinus edulis* Engelm.
Pine, ponderosa	*Pinus ponderosa* Laws.
Pine, Scots	*Pinus sylvestris* L.
Redcedar, eastern	*Juniperus virginiana* L.
Sagebrush, big	*Artemisia tridentata* Nutt.
Serviceberry, saskatoon	*Amelanchier alnifolia* (Nutt.) Nutt.
Spruce, Engelmann	*Picea engelmannii* Parry
Sumac, skunkbush	*Rhus trilobata* Nutt.